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Featuring

Progress in Sewage Treatment Abroad

Engineering Features of a Modern Glass Bottle Plant

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JOURNAL OF THE

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Volume XV JUNE, 1928 Number 6

PROGRESS IN SEWAGE TREATMENT ABROAD

By Frank A. Marston,* Member, Boston Society of Civil Engineers

(Presented before the Sanitary Section, Boston Society of Civil Engineers, December 7, 1927)

The following notes on sewage treatment summarize briefly some of the more interesting points observed during June and July, 1927, in Great Britain, Holland and Germany. They do not cover the subject completely, especially with regard to Great Britain, but touch on certain important developments.

As might be expected, the activated sludge method of sewage treatment is the outstanding method used in new plants. The building of equipment on a large scale for the collection and utilization of methane gas from the digestion of sewage sludge is becoming more common, and is, perhaps, more interesting than the progress made along other lines of sewage treatment work.

Glasgow, Scotland

Effect of Gas Works Wastes on Activated Sludge Plant. — At the municipal gas works, in common with others in Great Britain, a change has been made from horizontal to vertical retorts, and this change has caused modifications in the phenol compounds discharged with the waste liquors into the sewers. The volume of these wastes and the changes in their character were sufficient to seriously affect the operation of the experimental activated sludge plant at Shieldhall, one of the city's sewage treatment works. As a result of this experience and that of some plants in England, it was thought that the mechanically agitated activated sludge units were more seriously affected than those agitated by compressed air.

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* Of Metcalf & Eddy, Consulting Engineers, Boston, Mass.

Coefficient of Interfacial Contact. — Large-scale and laboratory experiments have been carried on to determine the relation between the minimum effective amount of return sludge and the period of contact in the aeration tank. During the period of this experiment the rate of sewage flow and the volume of return sludge were carefully regulated, the detention period in the aeration tank was checked, and frequent analyses were made.

The Shieldhall unit was operated in this way for fifteen days. The minimum effective amount of sludge was found to be 8 per cent, as measured after one hour's settlement, with a contact period of 4.2 hours and an average sewage flow of about 368,000 gallons * per day.

The effectiveness of the action between the sewage and sludge particles, or the "intensity of the interfacial contact," with an adequate supply of dissolved oxygen constantly available, was believed to depend on —

1. The velocity and direction of movement of the mixed sewage and sludge created by the means of agitation used.
2. The ratio of the volume of sludge to the volume of sewage.
3. The period of contact as determined by the rates of flow of the sewage and sludge.

With a constant supply of air or with mechanical agitators the velocity of flow (1) may be considered as a practically constant factor. The controlling items are then (2) and (3). For this reason it was assumed that the numerical product of the minimum effective percentage of sludge and the hours of contact may be taken as an index or "coefficient of interfacial contact."

In the case of the Shieldhall experiments this coefficient is the product of 8 and 4.2, or 33.6. For other conditions the coefficient would be different.

From this coefficient can be obtained the required minimum effective percentage of sludge for a given period of contact by dividing the coefficient by the detention period in hours, or *vice versa.* This was further proved experimentally and by practical experience.† The use of this coefficient is said to have been of practical value at Shieldhall in making it possible to maintain good operating conditions and increased capacity of the plant.

Compressed Air v. Mechanical Agitation. — Laboratory experiments are said to have shown that the biological intensity of activated sludge is greater when compressed air is used for agitation than when mechanical means are employed. With the Shieldhall sewage, the practical limit of purification was reached in a four-hour contact period with compressed air, and an eight-hour period with the mechanical unit. Similar results were obtained on a large scale at Shieldhall with compressed air and with Sheffield system mechanical units.

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* References herein are to United States gallons.

† "Observations on the Biological and Physical Properties of Activated Sludge and the Principles of its Application," by F. W. Harris, T. Cockburn and T. Anderson. Paper read before the Association of Managers of Sewage Disposal Works, July 2, 1926.

These facts, based on both laboratory and plant tests, lead to the conclusion that with conditions as found at Shieldhall, compressed air agitation produces a more active sludge than the mechanical methods.

Achorutes Viaticus. — Some time ago the trickling filters at the Dalmarnock sewage treatment works became badly clogged with a tough, fibrous form of fungus, so that the surface pooled badly. It was decided to try to remedy the difficulty by the aid of the insect *achorutes viaticus* which had been found so successful at the Stratford-on-Avon sewage treatment plant by Mr. H. D. Bell.*

This insect measures about 2 millimeters in length, is of a blue-gray color, and consists of a head, thorax and abdomen of six segments.

The food of the insects is thought to be the slimy colloidal growths which form on the surface of the filter stone. It is also said that the insects feed upon the larvæ of the sewage fly, *psychoda*, which has been so troublesome in some places, and that where the achorutes is present in large numbers there is never any great quantity of psychoda.

A supply of slimy growth or coating colonized with these insects was obtained from Mr. Bell and was applied to experimental filters for the purpose of studying the habits of the insects and methods of propagation.

For a time the results were doubtful, due to the low vitality of the insects, but gradually they became accustomed to the change in conditions, and colonization progressed more rapidly.

An attempt was made to transfer slime-coated stone colonized from the experimental filter in the laboratory to one of the large filters at the plant by burying the colonized stone in the filter to a depth of about 6 inches. The results, however, were not satisfactory, as it appeared that the unavoidable disturbances and the change in conditions prevented the insects from becoming acclimated in their new surroundings.

Special boxes were then devised about 1 foot square and 6 inches deep with perforated removable bottoms. The boxes were filled with the filter stone and were inoculated from the experimental filters in the laboratory.

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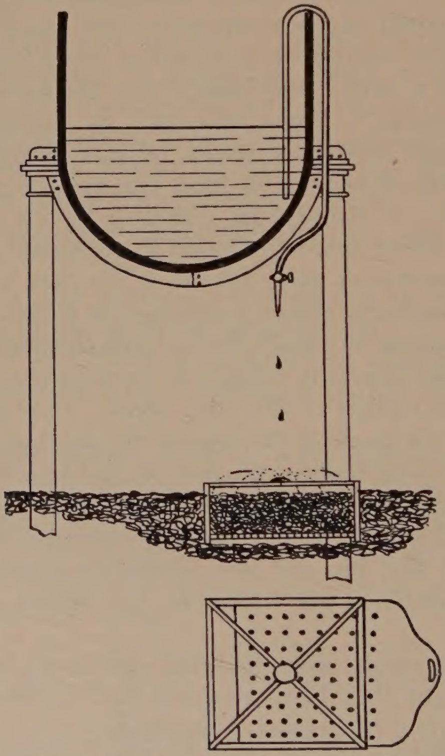
* "Insect Life on Sewage Filters," by Bell & Parkinson.

For badly ponded sections, the colonized stone in the box was transferred to the large filter by making a hollow in the filter deep enough to take the box. The stone was then replaced on three sides of the box and the bottom of the box removed. The stone was then replaced on the fourth side and the sides of the box were withdrawn.



"The Engineer" Swain Sc.

Fig. 1. — Method of Inoculation of Trickling Filters at Glasgow, Scotland

Another method found successful was to bury one of the boxes of colonized stone in the surface of a large filter under one of the metal distributing troughs, as shown in Fig. 1.* The sewage is distributed to the surface of these filters by Ames Crosta traveling type of water-driven sprinklers. Tank effluent from the trough was drawn out through a siphon tube and allowed to drop on the box, striking on a convex piece of wood, and causing a spray which distributed the effluent over the surface of the stone. The effluent trickling down through the colonized stone not only furnished a food supply, but also carried insects with it into the filter and gradually inoculated the entire filter.

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* The Engineer, February 10, 1922, "Sewage Filter Beds and the Achorutes Viaticus."

The trickling filters at Glasgow vary from 8 to 9 feet in depth, and the stone is so-called "whinstone," a very hard, dense material resembling our trap rock. The material to a depth of 2½ feet is 1½ inches in size, and varies from that to 3 inches in size at the bottom.

Apparently the insects eat holes in the fibrous fungus, permitting it to be broken up so that bacterial action can go on to further break up what remains. Since the 5¼ acres of filters have been inoculated, using four of the colony boxes to each 1-acre bed, the fungus has completely disappeared, it has not been necessary to clean or rake the beds, and there is now no surface pooling.

The insects have become accustomed to the conditions at Glasgow, where the winters are long and severe, and it is said that they are active in the winter as well as in the summer. The same insect has been found helpful in the Birmingham, England, trickling filters.

For much of the foregoing information the author is indebted to Mr. W. S. Tennant, general manager, and Mr. F. W. Harris, chemist, of the Glasgow Corporation sewage disposal works.

Sheffield, England

The sewage treatment plant at Sheffield serves a population of about 530,000 persons, and in addition treats the industrial wastes from steel mills, gas works, breweries and other industries. The plant handles an average dry weather flow of about 13,000,000 gallons per day, equivalent to 24.5 gallons per capita per day. The sewage is strong, and because of the wastes from the steel mills is quite acid.

The sewage receives preliminary treatment in detritus pits from which the deposits are removed by traveling bucket excavators mounted on a railway truck and provided with a belt conveyor to discharge the material into a freight car. A considerable portion, perhaps one-third, of the material removed is organic matter.

After leaving the detritus pits the sewage passes through inclined racks, mechanically cleaned, having a clear spacing of about 1 inch.

Preliminary sedimentation is provided in large, plain settling tanks, after which some of the sewage goes to the old percolating filters and contact beds, and the remainder is treated by the activated sludge process, according to the so-called "bio-aeration system."

The first large scale plant of the bio-aeration type was started in 1921, and is still in operation, treating the sewage of the Tinsley district of Sheffield. Additional units have been constructed and are in operation treating a part of the Sheffield sewage, and more units are in process of construction. The plan adopted provides for 12 large plant units, each of which consists of a continuous flow aeration tank, 9 settling tanks of the vertical flow, or Dortmund type, a gaging chamber, motor houses, pump houses and other appurtenances.

The aeration, or circulating, tank in each unit consists essentially of a tank 250 feet long by 30 feet wide, formed into 20 or more longitudinal channels, 6 feet in width, by concrete division walls, and so arranged that the sewage entering at one end flows back and forth through the continuous channel to the outlet end, where it is discharged over a weir into the settling chamber. From the outlet end a channel passes back to the inlet end, and thus makes it possible for a small portion of the sewage to pass back and around the circuit again with the incoming sewage.

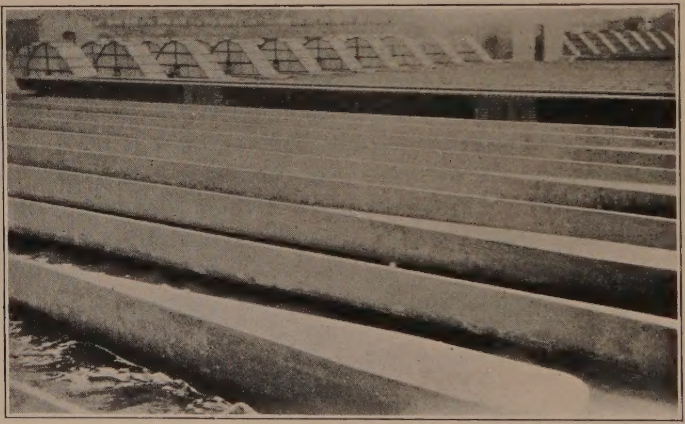

Fig. 2. — Aeration Tank at Sheffield, England

Each channel has a depth of 4 feet 5 inches below the sewage level. These channels are connected at the ends, forming a continuous channel in each plant unit from five to six thousand feet in length. (See Fig. 2.)

Forty minutes is the shortest time of flow through the tanks, and some of the sewage takes a much longer period.

Midway in each channel is a pair of paddle wheels supported on a transverse platform and driven by shafting also running transversely of the channels. There are two shafts varying from 3 to 5 inches in diameter, each shaft driving each alternate pair of paddles.

Each paddle consists of two sets of radial arms, 8 in number, made of steel angles, forming a rimless wheel about 10 feet in diameter. The paddle wheels are set on the shaft in the channel so as to divide the 6-foot wide channel into thirds. The paddles are revolved at the rate of about 15 revolutions per minute, which speed has been found to produce short waves on the surface of the sewage, which travel along the channel and around the end without undue splashing.

The channels have been designed with rounded ends and a rounded bulging division wall which, by experience, has been found to prevent deposits at the ends. A freeboard of about 2 feet is allowed to prevent splashing over the walls. If the speed of the paddles is too slow the waves created will cause splashing, and if the speed is too fast, insufficient aeration will be obtained.

Each set of paddle wheels has the effect of lifting the sewage about 2¼ inches. The paddles in each channel require about 1 brake horse power for driving. There are 21 or more sets of paddles in each line of shafting.

No trouble has been experienced with ice either in the channels or in the paddles, which latter, at Sheffield, are enclosed in a housing built of asbestos board. In colder climates it might be advisable to house the paddles in a heated building.

The sewage capacity of each aeration tank unit is about 960,000 gallons, and the tank unit is designed to treat an average dry weather flow of about 1.5 million gallons per day. An average of about 25 per cent and not over 30 per cent of the sludge from the sedimentation tank is returned to flow through the aeration tank with the sewage.

From early experiences at Sheffield it was thought that about 42 horse power per million gallons per day would be required to drive the paddles and for other uses, but later experiences have indicated that from 25 to 29 horse power will be required for average dry weather flow. These figures include about 4 horse power required for sludge pumping. It is said that somewhat less power will be required for a weak sewage.

The sewage after leaving the end of the last channel in the series passes through a transverse channel, the outside wall of which serves as a weir over which the sewage flows into the retention chambers and thence through conduits to the centers of the vertical flow settling tanks.

Each of the nine settling tanks in the plant unit is about 25 feet square, 22 feet 6 inches deep, and contains about 47,000 gallons. The sewage entering the tank flows downward through a central chamber, under the edge of the steel walls of the chamber and up and out over a weir on each of the four sides of the tank, thence through collecting channels to a gaging station, and finally is discharged into the effluent channel through which it flows to the River Don. The hopper bottom of each settling tank has a slope of 1½ on 1. During the seven years which the Tinsley plant has been in operation, there has been no shutdown, and the settling tanks have not required emptying in order to clean them.

Sludge is drawn from the bottom of the hopper of each tank continuously through a diagonal riser pipe, and is discharged by gravity into the sludge channel leading to the sludge pump. The discharge is controlled by a gate valve on the outlet, and is adjusted so as to keep the sludge in the settling tank at a level below which the volume of sludge will be equivalent to from 15 to 25 per cent of the tank capacity. The surplus sludge is dried on open beds built of ashes.

This plant has been described in detail because it represents a type which has proven successful and which has been adopted by thirty or more other plants, many of which are in operation. Plans have also been prepared for a standard plant of the same type for use in Holland.

It is said that the construction cost of a plant of this type is slightly less than that of a trickling filter plant, the operating costs are slightly greater, but the results as regards treatment are much better. The area required for the plant is somewhat larger per million gallons daily of sewage treated than for some other types.

Except for that noticed in the immediate vicinity of the paddles where the sewage is violently agitated, the plant was practically free from odor.

At Sheffield about three times the dry weather flow is passed through the plant during periods of storm water runoff. This increased storm flow is equivalent to but three-quarters the average per capita dry weather flow of municipal sewages in the United States.

Examinations of the dissolved oxygen content of the sewage in the aeration tanks have shown that there is no dissolved oxygen in the sewage where it enters the tank, but after a travel of about 200 feet dissolved oxygen is found, and from that point to the end of the tank dissolved oxygen is present in increasing amounts. The return sludge is discharged into the aeration tank channel about 50 feet behind the point where the sewage enters and thus at a point where the liquid has the highest amount of dissolved oxygen. In this way the return sludge gets a certain amount of reactivation before it encounters the incoming sewage.

A plant of this type, like others of a mechanical nature, depends upon the continuous action of the paddles or agitators. For that reason the equipment must be of the highest grade if serious interruptions in service are to be avoided.

For the foregoing data the author is under obligations to Mr. John Haworth, general manager of the sewage disposal works of Sheffield.

MANCHESTER, ENGLAND

At the Withington works of the Manchester corporation, treating the sewage from 71,000 persons, the oldest activated sludge units have been in use for about ten years. About one-third of the sewage is treated by the activated sludge process, and the remainder is handled by plain sedimentation tanks, Imhoff tanks and double contact beds.

The Imhoff tanks provide sedimentation for an average of 800,000 gallons per day, which is the approximate capacity for which they were designed.

The aeration tanks of the activated sludge plant are equipped with diffuser plates through which compressed air is forced to agitate and aerate the sewage. The air is furnished at a normal working pressure of about four pounds per square inch by vertical, reciprocating air compressors driven by electric motors. The overall efficiency of the newer compressor units is 52 per cent. Mufflers have been installed on the suction pipes to the compressors to reduce the noise which was objectionable.

In the large tank unit, treating an average of 1.3 million gallons per day, 0.9 cubic foot of free air per gallon has been used with an average detention period of seven hours. This tank is of the spiral flow type with aeration channels 6 feet 3 inches wide and 7 feet depth of sewage. The air consumption is equivalent to 5.4 cubic feet of free air per hour per square foot of tank area.

A small activated sludge unit of the ridge and furrow type, having a capacity of 72,000 gallons, has been in practically continuous and satisfactory operation for six years. The average daily sewage flow treated has been 400,000 gallons per day, and the quantity of air used from 0.9 to 1.1 cubic feet of free air per gallon of sewage, with a detention period of about four hours.

Further experiments are to be carried on to determine the relative efficiencies of the ridge and furrow system and the spiral flow type. Reaeration of the sludge has not been found advantageous.

Dr. Ardern gave the impression that he considered that the diffuser system with compressed air was more flexible in operation, required a shorter detention period, and consequently less tank capacity, and in general was better than the mechanically agitated systems. This question, however, will be studied on a large scale at the Davyhulme works of the Manchester Corporation, where three activated sludge units are to be built and operated in parallel, one with diffuser plates laid longitudinally (spiral flow system) on a ratio of about 1 to 15, a second with Simplex mechanical agitators, and the third with the Sheffield paddle system.

A new type of mechanically cleaned coarse screen is being installed at the Davyhulme works. One demonstration unit had been in use for sixteen months before the large installation of 4 units was decided upon. Each of these large units is 39 feet long by 8 feet wide.

The screen unit consists of a continuous wire rope, 3/16 inch in diameter, wound helically around top and bottom drums at the ends of a frame. The frame is set in the chamber at a flat angle so that the suspended solids ride up on to the rope strands as they travel up and out of the sewage. The clear spacing between the ropes is ¾ inch in the large units and ¼ inch in the demonstration unit.

The grooved pulleys on the bottom drum are loose on the shaft, as are also all but the two driving pulleys on the upper drum. These features, together with counterweights led over pulleys at the top, are intended to take up the slack and produce even tension on all of the rope strands.

The screenings are brushed off on the return side by revolving brushes, made of basswood, located just below the upper pulleys. A row of revolving steel wire brushes is also used to remove fibrous material left by the wooden brushes.

The spacing of the rope strands on the ascending side is maintained by several rows of grooved guide pulleys driven at the same speed as the rope.

The Withington works were visited in company with Dr. Edward Ardern, consulting chemist of the Rivers Department, from whom much of the foregoing information was obtained.

Birmingham, England

The sewage of the city of Birmingham and of a number of adjacent communities is treated at three sewage treatment works built and operated by the Birmingham, Tame and Rea District Drainage Board.

The principal plant in the valley of the Tame River treats an average dry weather flow of about 35,000,000 gallons per day. The total population served by all three plants is nearly 1,100,000 and the dry weather flow is over 38,000,000 gallons per day.

The principal plant is divided into two parts, — the primary treatment works at Saltley, and the secondary or final treatment works at Minworth.

These works have been for many years a source of great interest to sanitary engineers, because of the various processes of sewage treatment tried out experimentally and on a large scale, and because of the excellent work which has been done. From 1899 to 1924 Mr. John D. Watson was engineer to the Board, and is now serving as consulting engineer. Since 1924 Mr. H. C. Whitehead has served as engineer.

At the Saltley works the sewage first passes through a rack composed of bars 7 inches apart, and then flows through a V-shaped detritus pit 240 feet long, 14 feet wide and 19 feet deep. The pit is cleaned frequently by an electrically operated traveling dredger.

From the detritus pit the sewage passes into sedimentation tanks of which there are 8 divided into primary and secondary units and having a combined capacity of 13.8 million gallons. The sewage flows through these tanks with a velocity of 90 feet per hour and a detention period of ten hours. The secondary units are also used to mix the sewage and equalize the flow discharged to the Minworth plant. The sedimentation tanks are cleaned by drawing off the top water and pumping out the sludge, which is done once in seven to ten days.

The sludge from these tanks and from other parts of the works is discharged to separate sludge digestion tanks of which there are 47 having a total capacity of nearly 62,000,000 gallons. The annual volume of fresh sludge treated in these tanks amounts to over 400,000 tons * (1.2 billion gallons) containing 8 per cent of dry solids.

The digestion of sludge is aided by a thorough inoculation of the fresh sludge with ripe sludge, either obtained from another digestion tank or by leaving ripe sludge in the digestion tank into which the fresh sludge is to be discharged. During the cold months both means are used, but during the warmer months it is only necessary to leave a sufficient quantity of ripe sludge in the tank in order to assure prompt starting of the digestion process in the fresh sludge. In very cold weather it has been found advantageous to inject steam into the conduit conveying the sludge to the digestion tank.

The fresh sludge is pumped first to primary digestion tanks, where

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* 2,200 pounds each.

it is allowed to remain for three months, and then is removed to secondary digestion tanks for a final digestion period of two months. In this way a more uniform and better drying material is obtained.

The digestion process results in the giving off of large volumes of gases which in general have been found to contain 67 per cent methane, 30 per cent carbon dioxide and 3 per cent nitrogen. The calorific value of the mixed gases is said to be 625 B.t.u.

Experiments made on the collection of the gas have been so satisfactory that one-third of the area of the primary digestion tanks has now been covered with concrete sectional covers which float on the sludge. These concrete covers are built in sections like pontoons, and are floated on the sludge and held in place by being chained together. Each section is 20 feet long by 10 feet wide by 4 feet deep, and contains a central pyramidal collecting hood from the top of which the gas is taken through a small pipe to the gas main laid along the side of the digestion tank.

The concrete covers were constructed 2½ inches thick by means of sectional steel forms, using a fine aggregate and a quick-setting, high alumina cement known as *ciment fondu*. The sections were made near the digestion tanks, and when the concrete was set, a section was picked up by an overhead crane and lifted into the digestion tank.

The gas collected from the digestion tanks under a pressure of 17 inches of water is piped to the power house, where it is used to run a 150 horse power internal combustion engine, generating electricity for the pumping of sludge and other plant purposes. It is expected that another unit of the same size will be installed, and it is hoped that a large part of the power required for the plant may be obtained in this manner.

The sludge when digested is pumped from the secondary digestion tanks through a pipe line 4½ miles long to the sludge drying beds at Minworth, which have a total area of 66 acres. These are filled twice a year with sludge 18 inches deep, which when dry enough to remove reduces to a thickness of 6 inches. About 30,000 tons * per year of dry sludge containing 10 to 20 per cent moisture are handled, a small portion of it being sold to a fertilizer manufacturer and the remainder used for filling low lying lands.

The sedimentation tank effluent from the Saltley works is conveyed to the Minworth plant and received some fresh sewage on the way. At Minworth the sewage passes through 34 silt tanks of the vertical flow type, maximum velocity 14 feet per hour in tanks, and then is distributed over the surface of the trickling filters, of which there are 52 acres. Part of the sewage is applied by means of mechanically operated distributors, but the greater portion is discharged through fixed nozzles.

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* 2,200 pounds each.

A few years ago it became necessary to increase the capacity of the works, either by extending the trickling filter plant or by other means, to care for the increasing flow of sewage. As a result of experiments, a large-scale demonstration plant was built and is now being increased to a total capacity of 9,000,000 gallons per day. This plant, which provides the activated sludge or so-called bio-aeration process, has three essential parts, — the flocculation or aeration tanks, the sludge settling tanks, and the sludge conditioning tanks.

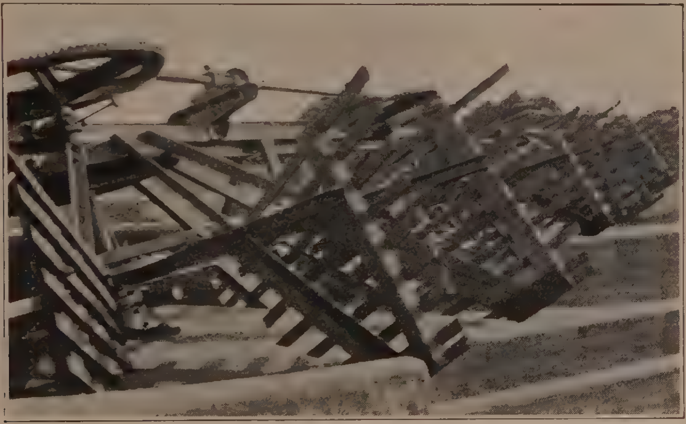

Fig. 3. — Hartley Type Paddle Wheels in Flocculation Tank at Birmingham, England

Each flocculation tank consists of a series of channels 4 feet 8 inches wide, with a water depth of 4 feet and a total length of travel of 3,360 feet. These channels are laid out in straight runs of about 180 feet each. At each return bend in the channel is an inclined paddle wheel of the Hartley spiral flow type, shown in Fig. 3. These paddles are revolved at a speed which imparts to the sewage a velocity of flow of 1 foot per second. The straight part of each channel contains a number of baffle plates, illustrated in Fig. 4, which can be adjusted diagonally to the flow to cause a spiral motion in the sewage as it flows longitudinally. This motion is said to aid in keeping the sludge in suspension at lower longitudinal velocities. The period of detention in the flocculation tanks is one hour, which is small compared with the period of aeration used at plants like Sheffield, where equivalent preliminary sedimentation of the sewage and final treatment on trickling filters are not provided.

The volume of return sludge amounts to 2 to 5 per cent, as compared with 20 per cent or more commonly used in some other types of plant.

The effluent from the flocculation or aeration tanks is then passed through the settling tanks, of which there are three 60 feet square, 32 feet total sewage depth, with 4 pyramidal hopper bottoms to each tank. The sewage is discharged at the center of the tank, through an upturned elbow, flows under a low baffle wall, and then up and out over a continuous weir on four sides of the tank. The effluent from the tanks flows to the trickling filters, and the sludge is discharged by the pressure of the sewage above to the sludge conditioning tanks.

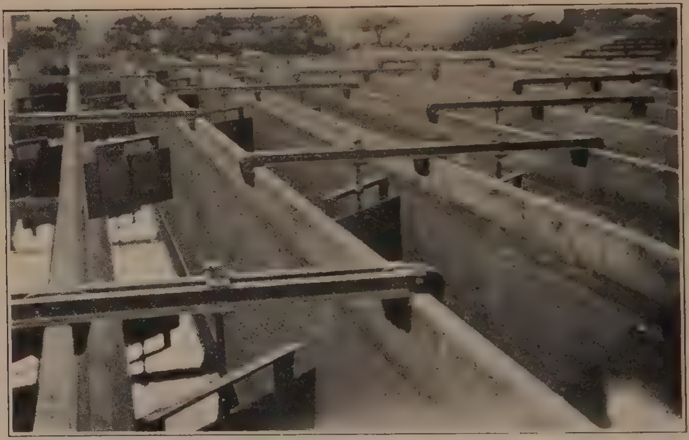

FIG. 4. — CHANNELS AND BAFFLE PLATES IN FLOCCULATION TANK AT BIRMINGHAM, ENGLAND

The sludge conditioning tanks consist of 15 square tanks equipped with mechanical agitators of the Simplex type and longitudinal flow channels of V-shaped cross section having diffuser plates for compressed air aeration, the whole providing from fourteen to twenty hours' detention period. The diffuser plates are set diagonally to the flow. Either or both types of aeration can be used. One of the Simplex agitators is shown in Fig. 5.

The Simplex type of agitator is set in the center of a square hopper bottomed tank. It consists of a vertical cylinder extending from the surface of the sewage to a point near the bottom of the hopper, and a revolving cone with blades set in the top of the cylinder. When the cone is revolved, the sewage is drawn up through the cylinder and discharged out over the surface of the liquid, causing considerable breaking up of the liquid and entrainment of air which is carried down into the liquid in the tank as the sewage recirculates toward the bottom of the cylinder. The sewage flowing through the tank is circulated up and down through a spiral path in each unit, and thence longitudinally across the unit to the outlets.

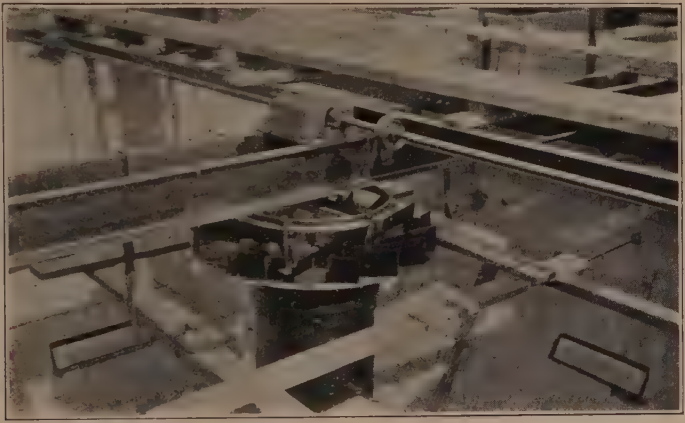

Fig. 5. — Simplex Agitator in Sludge Reconditioning Tank at Birmingham, England

In these tanks the sludge is reconditioned before a portion of it is pumped back to the flocculation tanks. The surplus sludge (without reactivation) is pumped to digestion tanks and is treated in the same manner as the sludge from other portions of the works.

Some of the advantages claimed for this method of treatment of sewage before its discharge to trickling filters are the prevention of odors when the effluent is distributed over the trickling filters, the elimination of the psychoda flies, and the ability to nearly double the rate of dosing the trickling filters.

The activated sludge process used in conjunction with sedimentation and trickling filters instead of alone reduces the liability of a serious disturbance in the purification process, by variations in the character and quantity of industrial wastes.

Mr. Whitehead has stated that each activated sludge plant should be designed for the particular sewage to be treated, and that the copying of a successful plant treating some other sewage may be disappointing. The Birmingham experience has shown the value of adequate preliminary sedimentation for the sewage before it enters the activation process. The degree of mixing in the aeration tanks should be much the same, regardless of the strength of the sewage, but the detention period must be increased for the stronger sewages, and the provision for aeration must be capable of variations.

The present tendency in England appears to be toward increased periods of aeration.

It is thought by some, including Mr. Whitehead, that the greater part of the oxygen taken in by the sewage is absorbed at the agitated surface of the liquid. If this is so, the strong sewage will require a greater surface area of aeration tanks, and possibly a different depth of liquid than a weak sewage. It is also important to provide means for readily increasing aeration without being forced to increase the power required for mixing.

The information given was obtained from Mr. Whitehead during a visit to the works, and also from the following publications of the Board: "The Works of the Birmingham, Tame and Rea District Drainage Board, 1926," and "History of the Birmingham, Tame and Rea District Drainage Board, 1927."

An interesting summary of operating troubles with activated sludge plants in England will be found in a discussion by Dr. H. T. Calvert of the Ministry of Health, Mr. Whitehead, Dr. Ardern and others in "The Surveyor," March 18, 1927, page 309.

Since writing the foregoing, a paper has been published on "Power-Gas from Sewage-Sludge at the Works of the Birmingham, Tame and Rea District Drainage Board," by Vokes & Townsend, Proc. Inst. C.E., 1928, which contains a detailed account of the work done on gas collection and utilization.

Holland

Much of the sanitary engineering work in Holland is being carried on under the direction or at the instigation of the government. Matters relating to the treatment of sewage and industrial wastes come under the supervision of the governmental Bureau on Sewage Treatment, of which Mr. H. J. N. H. Kessener is the director. The majority of the plants thus far built treat industrial wastes to prevent serious contamination of the canals.

In 1912 an extensive report was published by a commission on the purification of the waste waters from strawboard and potato flour works, and about that time a plant was built at Sappemeer for the treatment of the wastes from a strawboard factory, and a small septic tank was provided with a dome for collecting the gases. The report of the commission above mentioned refers to experiments made in 1909 at Sappemeer on the quantity of gas to be obtained and its characteristics. In 1913 a large plant was constructed at Sappemeer for the collection of gas from the septic tanks of the strawboard factory, and the gas was used to run a gas motor to generate electricity. In February, 1914, a patent was granted by the German government to Mr. Kessener, covering certain phases of gas collection and the use of gas from the digestion of sewage sludge. In 1915, in "Purification of Some Trade Waste Waters," by H. A. Van Ysselsteyn, Director-General of Labor, attention was further called to the early experiments and work on gas utilization by Mr. Kessener.

Thus it will be seen that for more than ten years the question of gas collection and utilization has been studied in Holland.

Recently Mr. Haworth of England has designed a typical activated sludge plant for the Dutch government, following the latest designs developed at Sheffield. These plans are intended to be used in Holland as a standard type for certain cases, and a plant of this kind is now under construction at Ede, to treat the sewage and wastes from an artificial silk works employing 4,500 persons.

Another type of works making use of the activated sludge process, has just been completed at Apeldoorn, to treat the wastes from the community abattoir, and having a capacity to handle a maximum flow of 30,000 gallons per day.

The plant consists essentially of tank compartments for detritus, sedimentation, separate sludge digestion, aeration and final settling, and a sludge drying area. At first the wastes pass through a coarse rack and then are given a short period of sedimentation in a Dortmund type of detritus tank, to remove sand and the coarser solids. From this detritus tank the sewage will pass through a sedimentation tank from which the sludge will be drawn by gravity into a separate sludge digestion tank. The effluent from the sedimentation tank will then pass through an aeration tank where the sewage will be agitated by submerged revolving paddles and the surface will be broken up by means of a series of revolving brushes located at one side of the tank. From the aeration tank the sewage will pass through a final settling tank from which some of the sludge will be withdrawn by gravity to a sludge channel and lifted by means of a sludge wheel into a return channel through which it will flow back to the entrance of the aeration tank.

The surplus sludge will be drawn to the sludge digestion tank and thence to a sludge drying bed.

The submerged revolving paddles, of which there are six in a length of about 37 feet, are built of wood bolted to a steel shaft. Each paddle consists of two pairs of side arms each extending a distance of 3 feet 9 inches radially in opposite directions from the shaft, with three cross arms. The bearings supporting the shaft are lined with pok wood which when submerged does not require grease lubrication. These paddles will be revolved at a speed of about 7 r.p.m., so as to give the sewage a spiral motion as it flows through the aeration tank.

The brushes located on the surface and at one side of the tank will be driven at a speed of about 100 r.p.m., or at a rate that will thoroughly agitate the surface of the liquid. These brushes are made of cocoanut fiber of a type similar to those used on street cleaning machines.

Two of the largest problems that will have to be solved in the near future are the disposal of the sewage of Amsterdam and of The Hague. The sewage of Amsterdam is now discharged into the Zuyder Zee, where it is disposed of by dilution in the tidal currents. A project is already under way to close the mouth of the Zuyder Zee, fill in certain areas and make what will virtually be an enclosed basin. When this is done it will be necessary to carry the sewage of Amsterdam out to the North Sea, or treat it before discharging it into the new basin.

The sewage from The Hague and certain adjoining communities, a population of more than 400,000, is now discharged into the main canal a short distance from its outlet into the sea at Scheveningen Beach. Formerly the sewage of The Hague discharged into the canals, but the conditions created were so objectionable that it was found necessary to build intercepting sewers and convey the sewage to the point mentioned. The volume of sewage discharged into the canal near its outlet is so large that it apparently constitutes nearly all of the flow out of the canal. It is easily visible for some little distance into the sea, and evidences of it can be seen along the beach both to the northeast and to the southwest from the canal outlet. At the time of the author's visit many children were playing on the beach and in the water.

The Dutch people are famous for the cleanliness of their homes, and it is surprising that the conditions observed are permitted to continue. Scheveningen is the finest seashore resort in Holland, and is said to be patronized by many from adjacent countries. Therefore it may be a matter of sound business policy as well as conducive to good public health to improve the method of sewage disposal.

Appreciation is due Mr. Kessener for the privilege of visiting his laboratory and the plant at Apeldoorn and for the information given in this paper.

THE RUHR DISTRICT, GERMANY

The association of communities and interests known as the Ruhrverband was created in 1913 to clean up the River Ruhr and its tributaries, primarily as a means of relieving the burden of pollution on the water works. The work has progressed to the extent that in June, 1927, there were 36 sewage and wastes treatment plants in the district.

The influence of American ideas is seen in the Dorrco type of screen installed at Duisburg, and in the change from the curved channels and round form of the earlier Emscher tanks to the rectangular forms of the larger and newer designs.

ESSEN–RELLINGHAUSEN

This plant in Essen treats the sewage from a population of 37,000, and, in addition, the sludge from the sewage contributed by 8,000 persons. The sewage, amounting on the average to 5.8 m.g.d. is diluted with surface and ground water and contains but little manufacturing wastes. At times the sewage contains much mineral oil and at all times a high content of sulphates from coal mine drainage which aid in the production of hydrogen sulphide in the sludge. The character of this sewage is shown by the following average analyses expressed in parts per million:

	Essen-Rellinghausen	Typical American City*
Total suspended matter	180	199
Biochemical oxygen demand unfiltered . . .	310	180
Chlorine	84	39
Sulphates	339	–
pH value (not p.p.m.)	7.5	7.3

* Schenectady, New York, 1927.

The plant as originally constructed contained only a coarse rack, grit chambers, Emscher tanks and sludge drying beds, but has now been enlarged to include an oil separator, a separate sludge digestion tank, aeration tanks, settling tanks, power house, etc.

The sewage first passes through a coarse rack and then goes to the oil separator, shown in Fig. 6, which is a baffled chamber in which compressed air is forced through the sewage in the central section of the chamber causing oil and scum to form at the surface on either side of the baffled central aerated section. The scum and oil are skimmed off and the sewage passes on to the grit chambers. Following the grit chambers there are six settling tanks of the two-story (Emscher or Imhoff) type. The detention period in the sedimentation compartment is only twenty minutes. This gave insufficient sedimentation until submerged contact aerators were installed in the last two out of three sections of each tank.

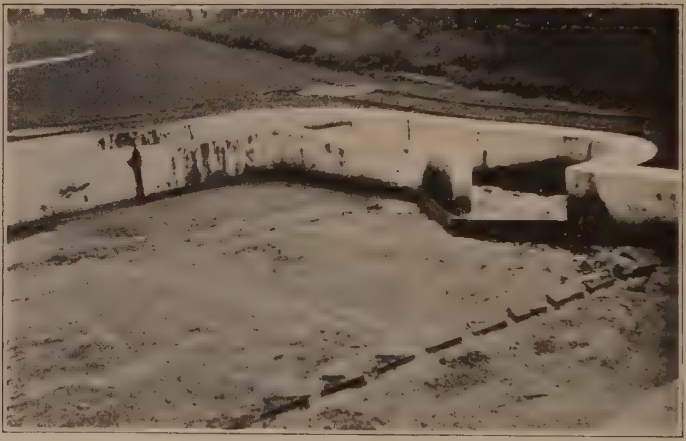

FIG. 6. — OIL SEPARATOR AT ESSEN-RELLINGHAUSEN, GERMANY

The submerged contact aerator consists of a box having an openwork bottom which is hung in the settling compartment of the Emscher tank. The box contains brushwood or crushed stone to provide a large area of surface. The contents of the box are aerated from below by a perforated air pipe which is made to swing back and forth under the box to cover the full area of the unit. The pipe is swung from the top of the tank by a device driven by an electric motor. Since the contact aerators were installed a material improvement in the effluent of the tanks has been noticed.

When the capacity of the Emscher tanks became overtaxed, a separate sludge digestion tank was built to aid in treatment of the sludge.

The separate sludge digestion tank has a capacity of 0.4 cubic foot per capita and the sludge compartments of the Emscher tanks have a volume equivalent to 0.7 cubic foot per capita. The separate sludge digestion tank also receives the surplus sludge from the activated sludge process.

The gas generated in the Emscher tanks is collected at the top of the gas vents in small pyramidal metal hoods, and the gas produced by the separate sludge digestion tank is collected by a fixed wooden cover with a gas hood at its center. A constant liquid level is maintained in the digestion tank by means of an overflow pipe.

The gas hoods are protected from scum rising on the inside by a loose wooden slot frames, resembling a series of grooves and splines, which allow the gas to pass through into the hood, but keep out most of the scum. It is necessary, however, to tilt back the hood from time to time and clean out the scum which has leaked through the protecting frame.

A portion of the gas, only that from the separate digestion tank, is burned in a small hot water heater, and the hot water (70–80° C.) is discharged continuously into the bottom of the digestion tank through the sludge draw-off pipe at a rate of less than 1,000 gallons per day. This small quantity of hot water provides sufficient heat to raise the temperature of the sludge from about 9° C. to an average of 21° C., and results in a more rapid and more uniform production of gas and digestion of sludge. This method avoids the difficulties experienced with heating pipes in contact with sludge. The gas from the Emscher tanks is sold to the city gas works.

The total gas production is in excess of 0.2 cubic foot per capita per day, and the content of methane is about 73 per cent. The gas is said to have a calorific value of nearly 900 B.t.u. per cubic foot.

The effluent of the Emscher tank passes to the aeration tanks where it is agitated and aerated by compressed air from diffuser plates set at one side, and further agitated by submerged revolving paddles, the design of which has been followed in the Apeldoorn plant previously described. The paddles, set on a horizontal shaft, revolve at a speed of 7 r.p.m. in a direction against the upward flow of air from the diffuser, causing some of the air bubbles to appear on the opposite side of the tanks from the diffuser plates.

The four aeration tanks are each 20 feet wide and 10 feet deep. Each tank is operated in two sections but without a longitudinal dividing wall. The detention period is approximately 3.5 hours for the average dry weather flow. The sludge returned, as measured after settling one hour, amounts to 8 per cent of the sewage flow treated.

It has been found that some degree of purification is effected with the air or the paddles. With both working, excellent results are obtained using only 0.08 cubic foot of air per gallon of sewage and a total power consumption of 7 horse power per million gallons of sewage treated.

From the aeration tanks the sewage flows to the settling tanks, entering at the center of each tank and flowing down under a central cylindrically shaped baffle and up and out over the peripheral outlet weirs. The detention period is one hour. Each tank is 66 feet square and of the vertical type, with a deep hopper bottom in which the sludge settles.

The sludge, which is pumped continuously from the settling tanks, passes through a revolving cylindrical screen made of wire mesh supported on a coarse screen over a steel framework. (See Fig. 7.) The coarser particles of sludge are removed and washed off by sprays of sewage effluent supplied by a motor-driven centrifugal pump. The sludge thus rejected is pumped at night, when the sewage flow is low, to the influent conduit of the Emscher tanks. Vertical shaft, motor-driven, centrifugal pumps are used for sludge pumping.

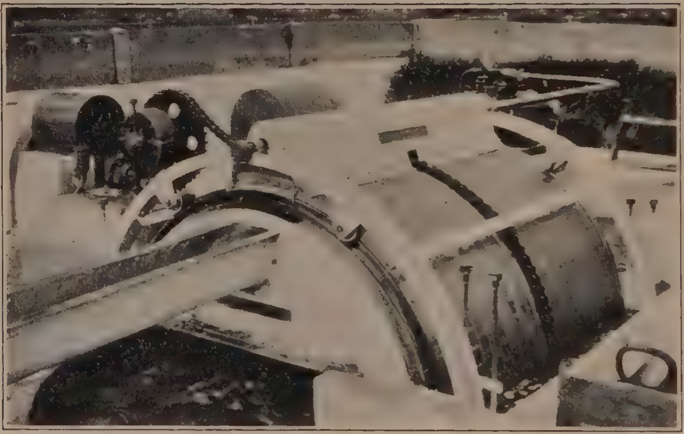

Fig. 7. — Revolving Screen for Activated Sludge at Essen-Rellinghausen, Germany

The sludge taken out by the screen is not quite enough to keep pace with the sludge increase, so at times it is necessary to waste some sludge in addition. The sludge as pumped from the settling tanks amounts to 16 per cent by volume of the sewage, and is large because of the water content. The excess sludge removed amounts to about 1 per cent.

Chlorine equipment is provided for use, if necessary, in disinfecting the final plant effluent, for complete disinfection, of which 1 part per million of chlorine has been found sufficient.

Experiments are now under way with triple contact aeration and are giving interesting results. A brief examination of the living organisms in the effluent from each stage of the process showed that the predominating forms in the effluent from the first contact stage were *paramecium* and *worms;* in the second contact stage, *cyclops;* and in the third and final stage, *daphnia.* The segregation of these forms was pronounced.

KETTWIG, GERMANY

At Kettwig the treatment plant received the sewage from a population of 6,300, and in addition a volume of wool scouring and textile wastes amounting to 60 per cent of the total flow at the plant.

The original plant contained only a rack, Emscher tank and sludge drying beds, but so much trouble was experienced with wool grease that a plant has been installed to treat the wool scouring wastes separately before they enter the Emscher tank.

The wool grease separating plant consists of a submerged contact aerator unit in which the wastes are aerated, causing a large part of the grease to separate out in the form of a thick froth on the surface of the liquid. On either side of the contact aerator unit is an overhead paddle frame which revolves slowly. One side is longer than the other. The short paddle pushes the froth towards the end wall of the chamber, and the long paddle pushes the froth over the wall and into a channel leading to the grease recovery plant. The effluent from the separating plant goes to the Emscher tank for further treatment with the sewage. The sedimentation compartment of this tank also contains a submerged contact aerator which aids in obtaining a better effluent from the tank.

WERDEN

The treatment plant at Werden serves a population of 12,500. Plain rectangular settling tanks are used to settle the sewage, and the sludge is removed continuously by traveling scraper conveyors to a sump at one end, from which the sludge is pumped to a separate sludge digestion pit in an abandoned quarry. The scraper equipment is similar to the installation at Indianapolis, Indiana, U. S. A. Piping is provided so that well-ripened sludge from the pit can be discharged into the sludge force main and thus seed the raw sludge as it is being pumped to the place of digestion. Sludge drying beds are provided near the pit for the disposal of the sludge.

OTHER PLANTS IN RUHR DISTRICT

Some idea of the character of other treatment plants under the control of the Ruhrverband may be had from Table 1 taken from "Der Ruhrverband," June, 1926, from "Die Arbeiten des Ruhrverbandes," June, 1927, both by Dr. Ing. Karl Imhoff, and from personal notes made at the time of the author's visit.

TABLE 1. — TREATMENT PLANTS OPERATED BY THE RUHRVERBAND

	Population served	Principal Features	Industry		Volume of Sewage (Gallons per Capita per Day)	Detention Period in Dry Weather (Daily Mean), Minutes (except as noted)	Temperature of the Sewage (Yearly Mean), Degrees C.	Capacity of Sludge Digestion Compartment (Cubic Feet per Capita)	Area of Sludge Drying Beds (Square Feet per Capita)
			Kind	Proportion of Total Sewage (Per Cent)					
A. Fine Screens									
Mülheim-Oberhausen-Duisberg.	240,000	Riensch-Wurl fine screens.	Coal, iron, tanneries.	50	140	–	16	–	–
B. Sedimentation Basins									
Hattingen-Stadt	14,000	Earth basins, 3.28 feet deep.	– –	–	26	3 hrs.	–	–	–
Haus Holte	7,500	Sludge lagoons	Coal	75	60	7 days	–	–	–
Heinrich Gustav	16,000	Sludge lagoons	Coal	85	107	2 days	–	–	–
Schulte Suntum	34,000	Sludge lagoons	Coal	85	122	12 hrs.	–	–	–
Lüdenscheid - Friedrichstal.	16,000	With separate sludge digestion chamber.	Metal	33	45	4½ hrs.	12	17.5	0.92
C. Percolating Basins									
Herbeder Steinkohlen	–	Coal detritus, 3.28 feet deep.	– –	100	–	4 hrs.	–	–	–
Zeche Mansfeld I	–	Coal detritus, 6.56 feet deep.	– –	100	–	8 hrs.	–	–	–

TABLE 1. — TREATMENT PLANTS OPERATED BY THE RUHRVERBAND — *Continued*

	Population served	Principal Features	INDUSTRY		Volume of Sewage (Gallons per Capita per Day)	Detention Period in Dry Weather (Daily Mean), Minutes (except as noted)	Temperature of the Sewage (Yearly Mean), Degrees C.	Capacity of Sludge Digestion Compartment (Cubic Feet per Capita)	Area of Sludge Drying Beds (Square Feet per Capita)
			Kind	Proportion of Total Sewage (Per Cent)					
Zeche Mansfeld II	–	Coal detritus, 3.28 feet deep.	– –	100	–	2 hrs.	–	–	–
Bommern	250	1.97 feet deep	– –	–	16	5 hrs.	–	–	–
Oelbach	81,000	Cableway, 1 foot deep.	Coal, iron	80	234	20	13	–	–
Velbert	10,000	1 foot deep	Hardware	5	52	20	10	–	–
Eibergbach	10,000	0.4 foot deep	– –	–	22	35	14	–	–
Schwerte (preliminary)	5,000	0.66 foot deep	– –	–	54	27	10	–	–
Schwerte (Railway)	500	1 foot deep	Railway works	95	–	44	20	–	–
Geisecke (Railway)	150	0.5 foot deep	– –	–	166	120	–	–	–
Lüdenscheid-Elspetal	8,000	1 foot deep	Metal	50	101	41	11	–	–
D. Emscher Tanks									
Steele	30,000	– –	Coal	85	156	100	18	1.26	0.39
Hattingen (Savings and Building Association).	2,000	– –	– –	–	39	180	16	1.26	0.81
Hattingen (Railway)	80	– –	Railway station	95	–	50	16	–	–
Welper	2,000	– –	– –	–	65	100	12	0.74	–
Essen-Bredeney	150	– –	– –	–	26	120	16	1.12	–

Hagen . . .	70,000	Partial gas collection; chlorination	Iron, textile	20	87	74	11	1.30	–
Iserlohn . . .	17,000	Storm water treatment plant.	Hardware, metal	10	48	197	13.5	2.24	0.57
Witten . . .	22,000	– –	– –	–	86	80	11	1.30	0.73
Arnsberg . .	5,000	Reconstructed old basins.	– –	–	36	180	–	1.05	0.28
Dahlhausen . .	7,000	– –	Machine works	10	48	100	–	1.86	–
E. Biological Plants									
Kettwig . . .	6,300	Contact in aerated Emscher tanks and gas collection.	Woolwashing; cloth mill.	60	75	60	16	1.75	0.52
Langendreer . .	30,000	Contact in aerated Emscher tanks and gas collection.	Coal, wire works	20	91	60	13	1.26	0.63
Essen-Rellinghausen	37,000	Emscher tanks activated sludge and gas collection.	Coal	66	156	20*	15	0.91†	0.17
Essen-Rellinghausen (auxiliary settling plant).	8,000	Aerated settling tanks	– –	–	35	100	11	–	–‡

* Detention period of Emscher tanks 20 minutes; whole plant, 4 hours.

† Also 0.5 cubic foot in separate sludge digestion chamber.

‡ Sludge is pumped to the large Essen-Rellinghausen plant.

The sewage of the three cities — Mülheim, Oberhausen and Duisburg — located near the mouth of the Ruhr is carried by a reinforced concrete intercepting sewer 6.8 miles long to the Rhine. The treatment used is fine screening and the removal of oil is by oil separators. The screens are of the Riensch-Wurl type, with the exception of the Duisburg, which is of the Dorrco pattern. Further treatment is not considered necessary because of the ample dilution afforded by the River Rhine. Plants along the Ruhr, however, provide of necessity a greater degree of purification, varying in extent as the local conditions require.

The auxiliary settling plant at Essen-Rellinghausen (8,000 persons) has a settling tank with a steep hopper bottom to facilitate sludge removal.

Settling tanks with sludge scrapers of the Dorr clarifier type have been installed at Herbede.

Several plants, as, for example, in the Oelbach district at Haus Holte (7,500 persons) and on the Oese (20,000 persons), make use of sludge lagoons.

Percolating basins, the so-called "sickerbecken," have been installed in the coal-mining sections to reclaim coal and remove other suspended matters from waste waters where the sludge is predominantly mineral. The percolating basin consists of a basin enclosed by masonry walls or earth embankments, relatively shallow in depth and provided with a flat sloping bottom leading to two or more lines of drain tile over which is a bed of coarse slag or cinders. Above the cinders is a filter bed of sand, ashes or crushed coke. The basins are used alternately as fill and draw settling tanks and sludge drying beds. The filter bed requires renewal from time to time as the material is taken away with the sludge. Shallow basins of this type, with a filter depth of 1 foot, were built during the post-war emergency period, and they have served well as preliminary settling tanks.

In all of the newer Emscher tanks as much area as possible is given over to the sedimentation compartments. The gas vents are made as small as possible, more nearly resembling manholes. All of these vents are fitted with gas collectors, and wooden slat frames are used to hold down the scum. It has been found of advantage to have small volumes of fresh sludge continuously coming in contact with digested sludge rather than to have a large accumulation of fresh sludge form in a separate mass. Heat applied to the sludge is also beneficial.

Objectionable odors from the sludge lagoons at Lüdenscheid-Friedrichstal have been eliminated by transforming a large settling basin into a separate sludge digestion tank.

Storm water basins are installed at Iserlohn and Velbert.

Submerged contact aerators are being operated in a number of plants in addition to those previously described.

At Hengstey a river settling plant has been constructed by building two weirs 13 feet high each across the Ruhr forming a lake 2.5 miles long and 1,300 feet wide, and of sufficient capacity to give a detention period of thirty-six hours at low water stages, to precipitate out the iron sludge and other suspended matters brought in by the River Lenne. The precipitation is accomplished as a result of this mixing of the acid iron wastes with alkaline wastes from cellulose and paper mills. The sludge will be discharged down river when the water is high without damage to the various water works. The development also includes a low head, hydro-electric power plant of 120,000,000 k.w. hours yearly output, and a public recreation ground.

For the foregoing information the author is indebted to Dr. Ing. Karl Imhoff, chief engineer, and to Dr. Friedrich Sierp, chemist, of the Ruhrverband, under whose direction these works have been constructed and are being operated.

In closing, it is fitting that appreciation should be expressed for the many courtesies extended by the engineers in the several countries visited. The spirit of friendly co-operation with which an American engineer is received adds much to the pleasure and profit of the visit, and creates an obligation to reciprocate whenever engineers from across the sea come to this country.

ENGINEERING FEATURES OF A MODERN GLASS BOTTLE PLANT

By Edward H. Cameron*

It is trite to say that we take our modern conveniences for granted. Unless there is an especial reason we rarely take occasion to consider the long period of process development and the present problems of manufacture of the simplest articles of everyday life.

The study of such processes constitutes the business of the industrial plant engineer, and it is the thought of the writer that such engineers may be interested in a brief non-technical description of the manufacture of one of our commonest substances, — glass. Compared with other basic materials, such as steel, textiles and paper, there is very little literature covering the manufacture of this material.

Glass is used universally for containers, tableware, windows, windshields, light bulbs, insulators and many other purposes. The glass industry is one of the oldest, and our museums have exhibits of glass products of artisans who lived in the time of Pharaoh.

The manufacture of glass bottles depended, until very recently, upon manual processes. The delivery of the molten glass from the furnace, and its manipulation into the finished ware by mechanical means, presents many difficult problems, and it is only within the past twenty-five years that practical processes have been perfected making possible the elimination of the large force of skilled and unskilled labor formerly required.

The adoption of automatic machinery for the blowing of bottles has resulted in the complete metamorphosis of the glass factory. The entire factory and the equipment which it contains bear only slight resemblance to a plant which manufactured the same product fifteen years ago. The hand-blown bottle plant is rapidly becoming a rarity.

Our glass manufacturing centers were originally started in localities where the raw materials were to be found and where a cheap fuel was available in the form of natural gas or of coal for producers. These elements are still the most important to consider in studying plant location. Closeness to a supply of skilled men in the industry is of some importance, but not to the extent existing in industries which are farther removed from the transition stage between hand and machine methods, such, for instance, as in textiles. Proximity to the market for the ware manufactured is generally of minor importance, as the market for most types of bottles is national rather than local.

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*With Jackson & Moreland, Engineers, Boston, Mass.

General Arrangement

This paper will discuss the features of a typical modern glass bottle plant. In order that a clearer idea may be presented of the processes and equipment involved, the description will be confined in general to an actual case covering the remodeling of an existing plant. This plant is now operating with modern equipment. The changes contemplated will involve a general rearrangement of existing features and the provision of further manufacturing units. It will be well to preface the discussion of this particular plant by a brief description of the departments which are found to be in any typical bottle factory.

The following list covers the main features of a modern factory:

(*a*) The batch storage and mixing plant.
(*b*) The automatic factory proper, containing the furnaces and bottle blowing machines.
(*c*) The "lehr" or annealing oven section.
(*d*) The packing and inspection section.
(*e*) The warehouses for finished packed ware.
(*f*) Producer gas plant with gas mains (if producer gas is the fuel).
(*g*) Compressor plant.
(*h*) The mould shop for the manufacture and repairs of the moulds in which the bottles are blown.

The above items are essential to any plant. Depending upon the size of the plant and general operating policies, the following items will be represented more or less completely:

(*i*) Machine shop.
(*j*) Wood box factory for manufacture of boxes and crates.
(*k*) Paper factory for making corrugated and plain cartons and partitions.
(*l*) General service shops:
    Carpenter.
    Tinsmith.
    Pipe fitter.
    Painter.
    Electrician.
(*m*) Power plant unless power is purchased.

To return to the particular plant under discussion and to study the arrangement of the various typical departments just listed, we should refer to Figs. 1, 2, 3 and 4 accompanying this paper. These figures show the layout of the present equipment and indicate the rearrangement and additional equipment to be used.

It will be noted that one present furnace "A," with its bottle machines and annealing lehrs, will be retained in the present location. Several bottle machines and lehrs will be moved to new locations, as well as two compressors. The existing hand-poked producers will be scrapped and replaced ultimately by two modern automatic producers. As the electric power is purchased the major steam requirements are for the producers. These use a comparatively small amount of steam, and consequently the initial step contemplates the retention of the present small boiler plant. Space is provided for a new boiler plant when a fourth furnace is added. Several structures on the site of the new work are to be removed. The present railroad track arrangement is good, and very slight track changes are required for the new layout.

Several other arrangements were studied. The one shown was adopted because it involved the least expense and caused a minimum interruption of production during construction. It also fits the topography of the site well. However, it is not wholly ideal, a more desirable layout being indicated on Fig. 5 which shows a plant of the same capacity on a new site. Economic conditions dictated the adoption of the layout on the old site due to the investment in existing structures and equipment.

In general, the new layout will consolidate the various processes which are now widely scattered, and will allow a substantial increase in production on the same site. After the proposed initial changes are made to this plant, it will manufacture 270,000 gross of 8-ounce bottles (weighing 14 ounces each) per annum, operating three 24-ton furnaces twenty-four hours per day, working three shifts. The daily output will be 72 tons of finished ware requiring about 85 tons of raw material. Forty-six tons of coal will be used daily by the producers and boilers. These quantities indicate the importance of good railroad facilities.

GENERAL OPERATION

The raw material, consisting mainly of silica sand (SiO_2), soda ash (Na_2CO_3), limestone ($CaCO_3$), cullet (broken glass) and lesser ingredients, will be received in box cars at the batch plant and there stored and mixed. The mixed batch will be taken from the batch plant by an overhead

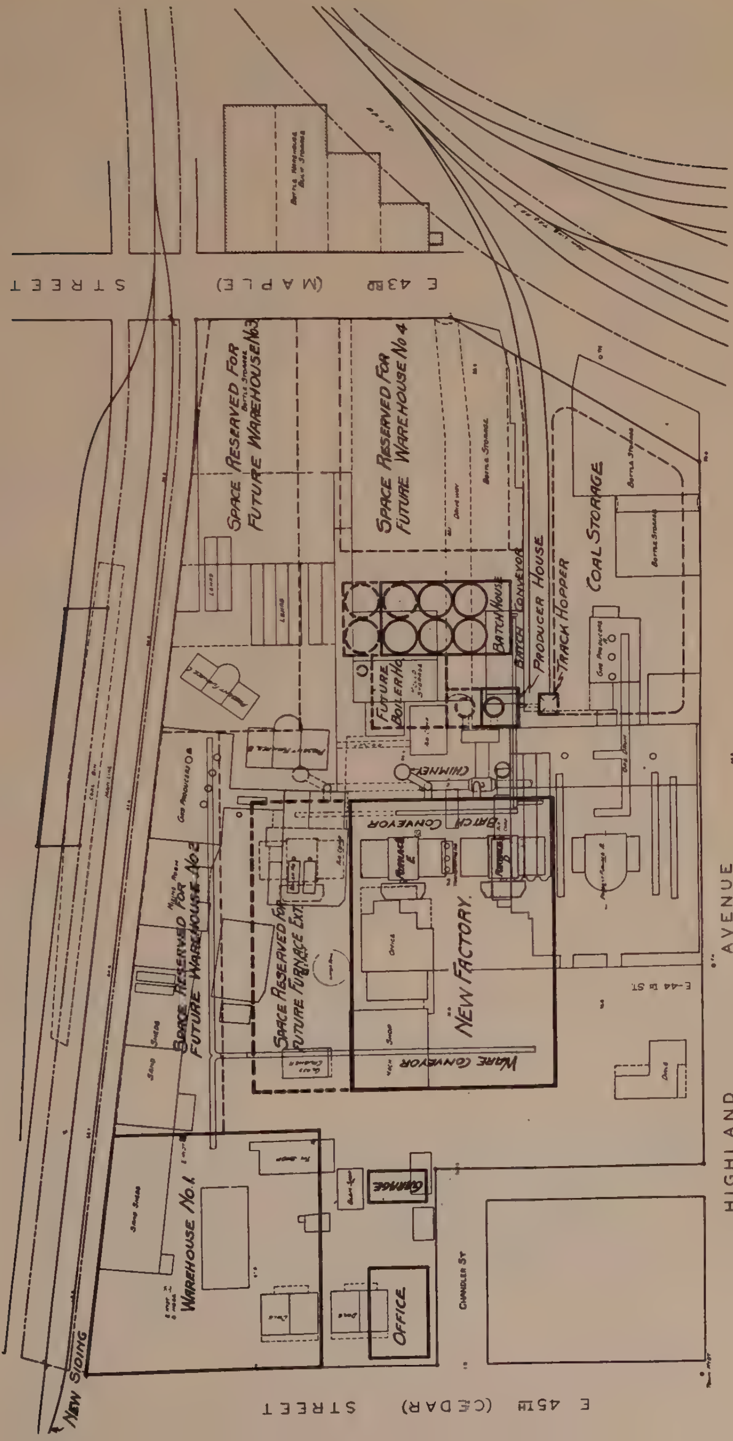


Fig. 1. — Present Site Development — Scheme 1

enclosed belt conveyor to a conveyor running the length of the factory. In front of each furnace there is a steel auxiliary bin which has a twenty-four-hour capacity. These bins supply the furnaces during the day and also during the night shifts when the batch plant is not running. The batch will be delivered to the furnaces at from twenty to thirty minute intervals. In the furnaces the batch is melted by means of heat from the combustion of producer gas and air. Each furnace holds about 140 tons, and the daily withdrawal is 24 tons.

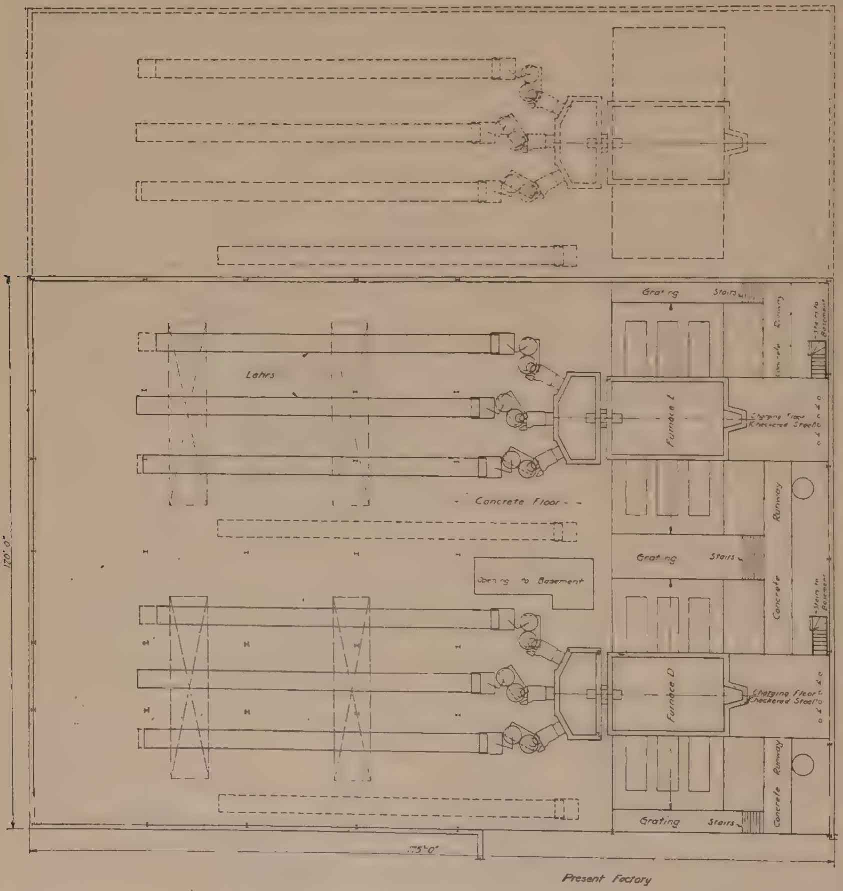


FIG. 2. — FACTORY WORKING FLOOR — PRESENT SITE, SCHEME 1

Reference to Fig. 2 indicates that each furnace will have, initially, three feeders which are designed to supply the proper amount of molten glass to the three bottle machines, the discharge being properly timed with the machine, and at the right degree of temperature and viscosity. In order that the molten glass may not "freeze" or congeal in the narrow passages of the feeders, additional heat has to be supplied at these points. This is usually attained by the use of oil burners which heat the slowly moving molten glass. The plant in question purchases byproduct gas from an adjacent manufacturer, and consequently uses this gas for maintaining the proper heat in the feeders instead of fuel oil. Each bottle machine carries moulds in which the gob of molten glass is received, formed, blown, partially cooled to be self-sustaining, and set out on a short conveyor. The delivery rate for the 8-ounce bottles is fifteen per minute.

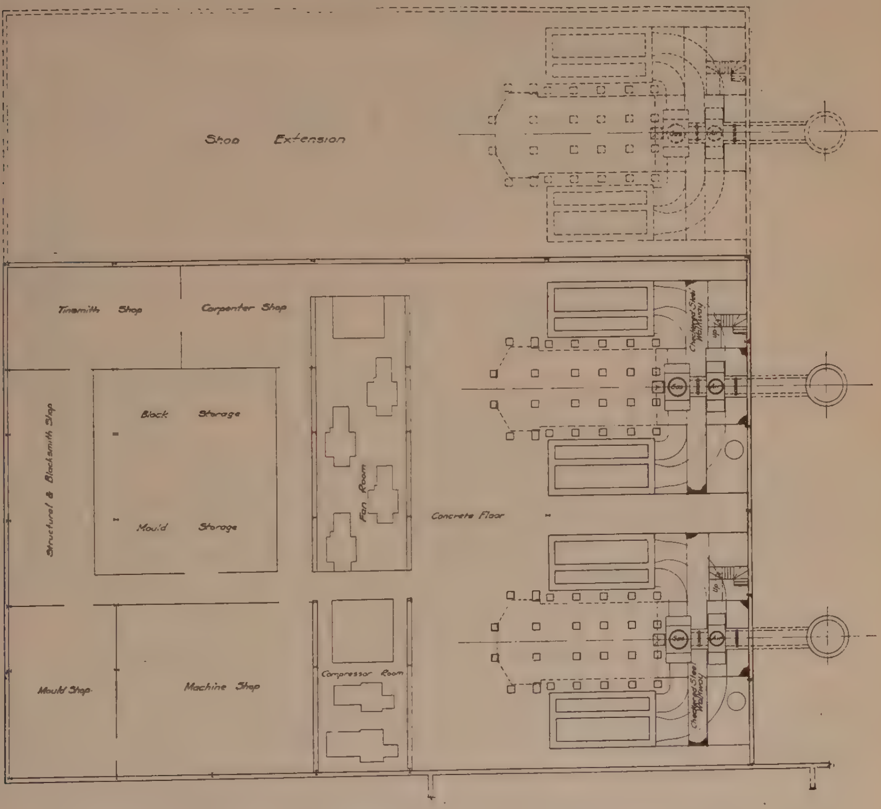


FIG. 3. — FACTORY BASEMENT PLAN — PRESENT SITE, SCHEME 1

Each machine has an operator to maintain its operation, but the bottle blowing and delivery is automatic. Machines are driven by compressed air at 35 to 40 pounds' pressure, which is reduced to a lower pressure for the blowing moulds. Automatic stackers will place each bottle in an annealing oven called a "lehr." One lehr is provided for each machine. The lehr consists of a chain fabric conveyor approximately 3 feet wide by 75 feet long. Sixty feet of the conveyor section is enclosed in an insulated housing. The passage of any one bottle through a lehr takes about two hours. This is an important stage of the process, and many types of lehrs for annealing have been developed. The bottles enter quite hot and leave at a comfortably warm handling temperature. An ideal lehr would require the addition of no heat in addition to that contained in the bottles. However, this ideal has not as yet been attained, and a small amount of heat from one by-product gas burner has to be supplied to the lehr. The annealing cools the bottle at the proper rate and removes temperature strains. Unannealed glass is very brittle and may shatter at slight changes in room temperatures.

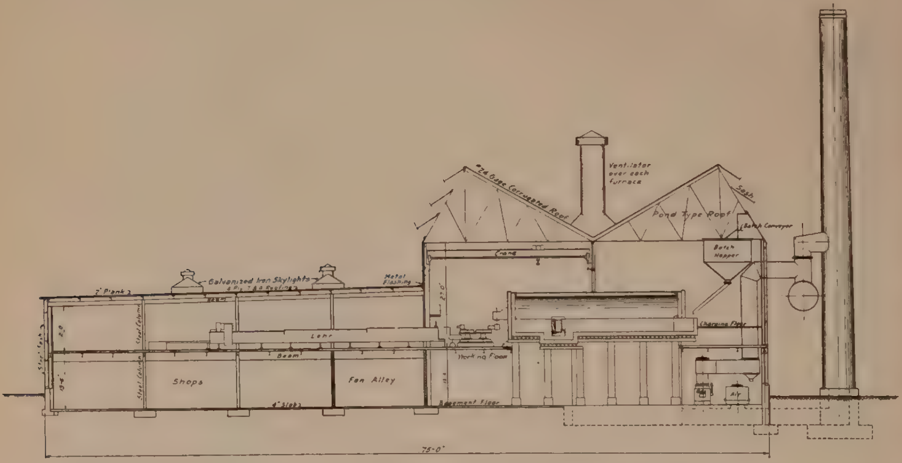


FIG. 4. — FACTORY CROSS SECTION — PRESENT SITE, SCHEME 1

At the cold end of the lehrs occurs the first-hand operation in the process. Here the bottles are inspected and packed in cartons, crates or trays according to the shipping requirements. A power-driven two-level belt conveyor is to run the length of the packing aisle back of the lehrs. Empty cartons arrive on the top belt and the packed cartons are placed on the bottom belt and travel to gravity conveyor branches leading to the warehouses whence they are shipped.

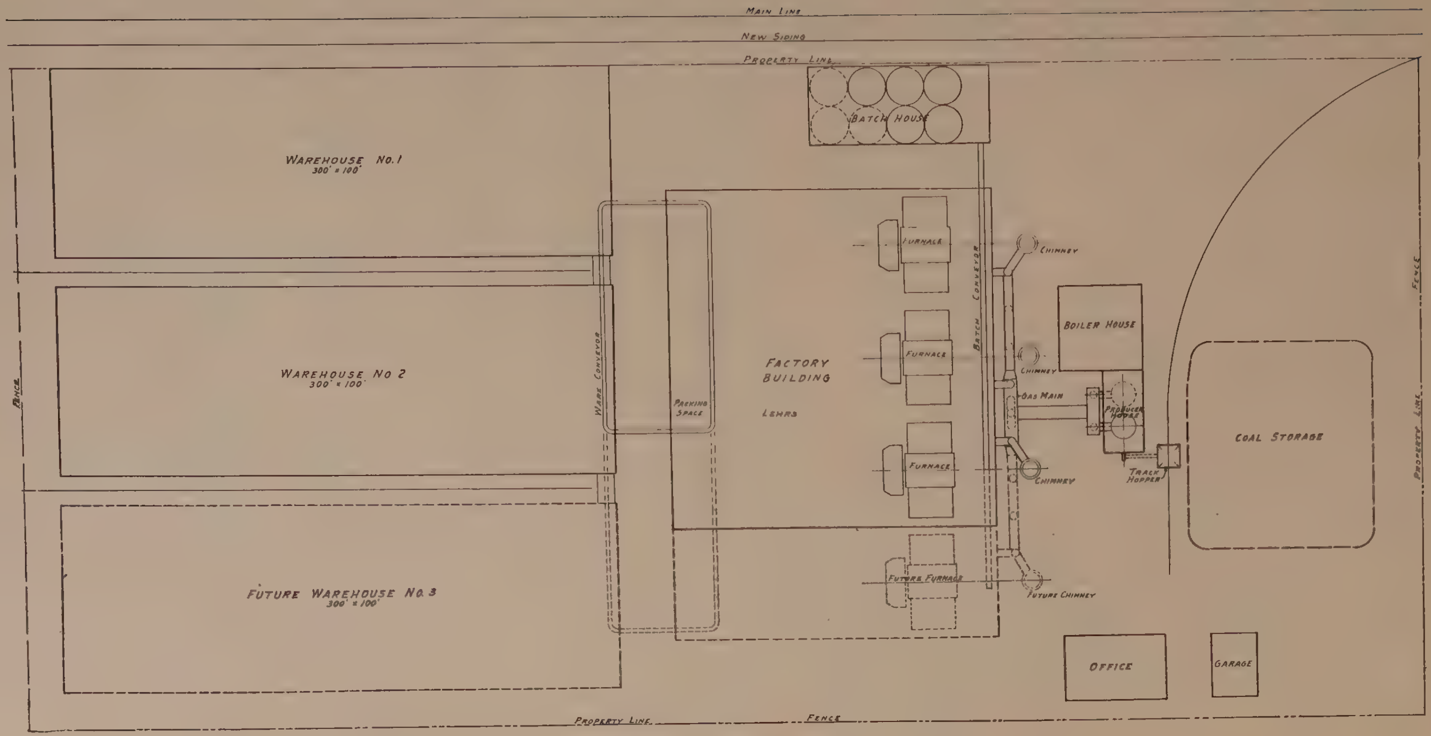


FIG. 5. — NEW SITE DEVELOPMENT — SCHEME 3

Power and Other Services

The major services for this plant are as follows:

(*a*) *Electricity*, to drive —
  Compressors.
  Furnace and machine cooling fans.
  Batch handling equipment.
  Coal handling equipment.
  Ware conveying equipment.
  Lehr conveyors and circulating fans.
  Shop equipment.
(*b*) *Compressed air* —
  For bottle machine operation.
(*c*) *Producer gas* —
  For melting glass in furnaces.
(*d*) *Steam* —
  For producers and building heating system.
(*e*) *Wind system* —
  For furnace cooling.
  For bottle machine cooling.
  For room cooling.
(*f*) *By-product gas* —
  For auxiliary furnace ports.
  For feeder burners.
  For lehrs.
    The above three services are more often rendered by oil burners requiring fuel oil and compressed air.
  For fire topping burners (to give smooth finish to bottle tops).
(*g*) *Cooling water* —
  For constant cooling of parts of furnace subjected to excessive heat.
  For cullet tanks for receiving rejected glass when feeders are operating but machines stopped.

The question always arises in the remodeling of a plant of this size as to just what policy should be adopted with respect to the power supply. For a large plant, it is possible to justify the investment required for a power house which will generate electricity and steam at least sufficient to care for the essential services.

The services required for a glass factory may be classified under the following headings:

(*a*) Safety services.
(*b*) Production services:
  Essential.
  Semi-essential.
(*c*) Auxiliary services.

A "safety service" is one necessary for the safety of life and equipment practically continuously for twenty-four hours a day, seven days a week, whether the plant is producing or not.

"Essential production service" is that which may be dispensed with for brief durations without danger to equipment, but even a brief cessation of which involves serious loss of production.

"Semi-essential production service" is that which can be cut off for longer periods without danger to equipment, and any cessation of which involves a less serious loss in production.

The main safety service in a glass factory consists of the furnace cooling wind supplied by motor-driven fans. Failure of this service may be very serious. The glass melting tanks of the furnaces have an average life of from eight to twelve months, after which replacement of side wall blocks is necessary. If the furnace cooling fans stop at a time when the walls of any tank have nearly completed their life, these walls are very liable to fail within a few minutes, and serious consequences may occur in the form of danger to life, and from fire. There is also the loss of production during the remaining tank life which would otherwise have been realized from this furnace, and its contingent equipment. This is a large factor, as it takes a long time to repair the damage from such an accident.

The compressed air for bottle blowing may be classed as an "essential production service." Failure of this service is very annoying and expensive, even for a momentary period. The writer had a demonstration of this fact recently when a fifteen-second outage of purchased power resulted in a fifteen-minute loss of production for the whole factory. Molten glass demands instantaneous manipulation. Consequently even a brief failure of blowing air means that ware in the machines is spoiled, the moulds overheat, and several minutes elapse during which imperfect bottles are being produced which must be scrapped.

By-product gas or oil and air for the feeder burners are "semi-essential production services." The feeders are devices which deliver the molten glass from the furnace to the bottle machines. Considerable ingenuity has been exercised by glass men in developing this part of the equipment, and the glass must be kept to exact temperatures, and the delivering operation precisely timed. Continuous heat is required during production, otherwise imperfect ware may result. However, brief outages of these burners do not cause the serious trouble resulting from the loss of blowing air, and they may be shut off for an hour or so during the Sunday non-producing shifts to allow repairs to piping.

This service is consequently classified as a "semi-essential production service." Burners for the annealing lehrs belong in the same category. Producer gas is a "semi-essential production service." If this service fails the glass in the furnaces may be kept hot by means of auxiliary oil or by-product gas burners, but the change-over may result in some loss of production.

The auxiliary services supply mould and machine shops, box factory, etc., and may be dispensed with in emergencies without loss of production. Considering all of the above factors it was decided that the present source of purchased power is sufficiently reliable, and that serious outages should not be expected frequently enough to justify the investment for a factory power plant.

BATCH PLANT

The batch plant consists of five (initial) circular storage silos 20 feet in diameter by 30 feet high (inside measure). These will provide an average storage period of about four weeks. The silos are to be constructed of hollow tile walls with reinforced concrete ring joints, and will have a common roof housing a conveyor gallery. Ultimately material will be stored in the interstices between the silos. A receiving chamber is located underneath the silos. Fig. 6 shows a batch plant similar to the one described above, except that steel silos are used and there is no conveyor gallery at the top.

There are three common types of commercial bottle glass: flint (white), green and amber.

The equipment and process for all three are similar, but more care and refinements are necessary at all stages in making the flint glass. The exact proportions of batch used are, of course, very important, and they vary with the type of ware produced, as well as with the kind of equipment and the properties of the raw material used. The entire process is under the direction of the plant chemist, who has to make frequent analyses of the batch as well as the product in later stages of manufacture.

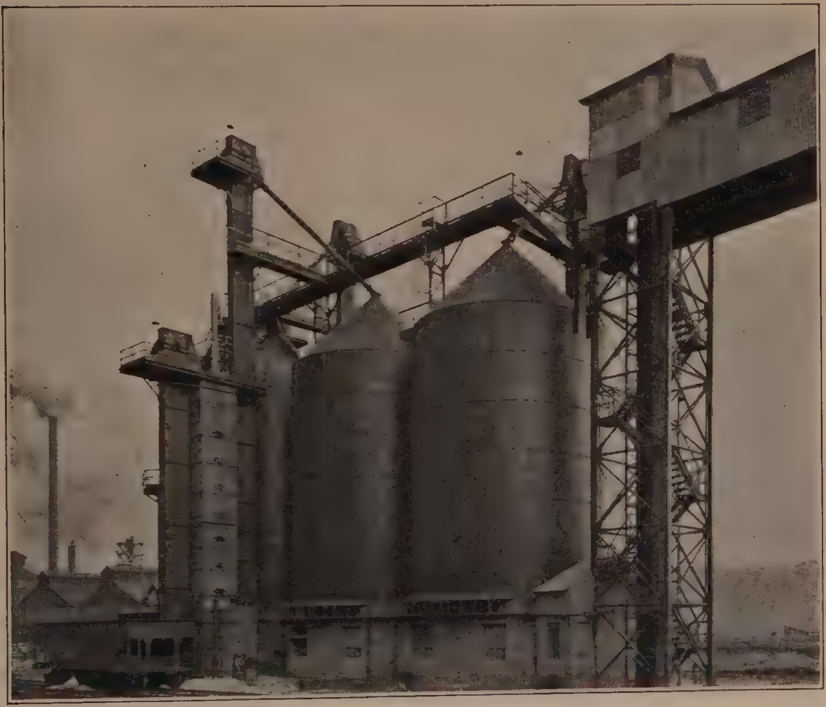
Rough batch proportions for flint or common white bottle glass for machine blowing are as follows:

Sand (SiO_2)	1,000
Soda ash (Na_2CO_3)	375
Lime ($CaCO_3$)	170
Cullet (broken glass)	400

Plus decolorizer and minor ingredients.

Some glass plants maintain their own sand quarrying plants, where cleaning, drying and handling systems are installed. The plant in question purchases its sand delivered at the batch plant.

The raw material comes to the batch plant in box cars. The unloading of the sand is a simple process, but difficulties are experienced with the lime and soda ash which are so dusty that the men in the cars sometimes have to wear gas masks. Suction systems are used in some instances, but these are expensive of power and usually a scoop scraper is used. A bucket elevator raises the material to the conveyor gallery, where it is delivered to the bins by means of a horizontal conveyor with plows or a tripper, or by means of chutes, to the respective bins.



Courtesy Link-Belt Company

FIG. 6. — TYPICAL BATCH PLANT

The service is very rough on the conveying system. Elevators are of the endless "Ore" belt type with steel buckets. Magnetic separators remove iron impurities from the sand and cullet. The cullet has to be washed and ground to proper size and a room is provided for this purpose.

The proper amount of material is withdrawn from each bin into a car which delivers it to the mixer. The mixing is similar to concrete mixing except that the materials are dry. Many plants use standard concrete mixers. The whole process is very dusty. All joints in bins and conveyors are made dust tight, and openings in the batch handling system are kept to a minimum. There is a tendency in the mixed batch for the materials to separate in the handling. Another difficulty arises from the tendency of the soda ash and lime to cake, all of which points have to be borne in mind in laying out the conveying and storage system.

The batch mixture consists of the sand, lime, soda ash and lesser items, the cullet being considered as a separate ingredient. The cullet may be either added at the batch plant or fed separately at the furnace. In the latter case the furnace auxiliary hopper must have a compartment for cullet. When the batch is mixed it is raised and conveyed to the factory conveyor and spilled into the auxiliary furnace hoppers. To avoid separation in these bins the expedient has sometimes been adopted of providing plate partitions forming cells some 30 inches square which tend to break up any hillsides down which the cullet may roll. Gates in the bottom of the furnace bin feed the batch into a steel chute serving the furnace, this operation being performed at stated intervals by the furnace attendant who is called the "shearer."

THE MAIN FACTORY AND THE FURNACES

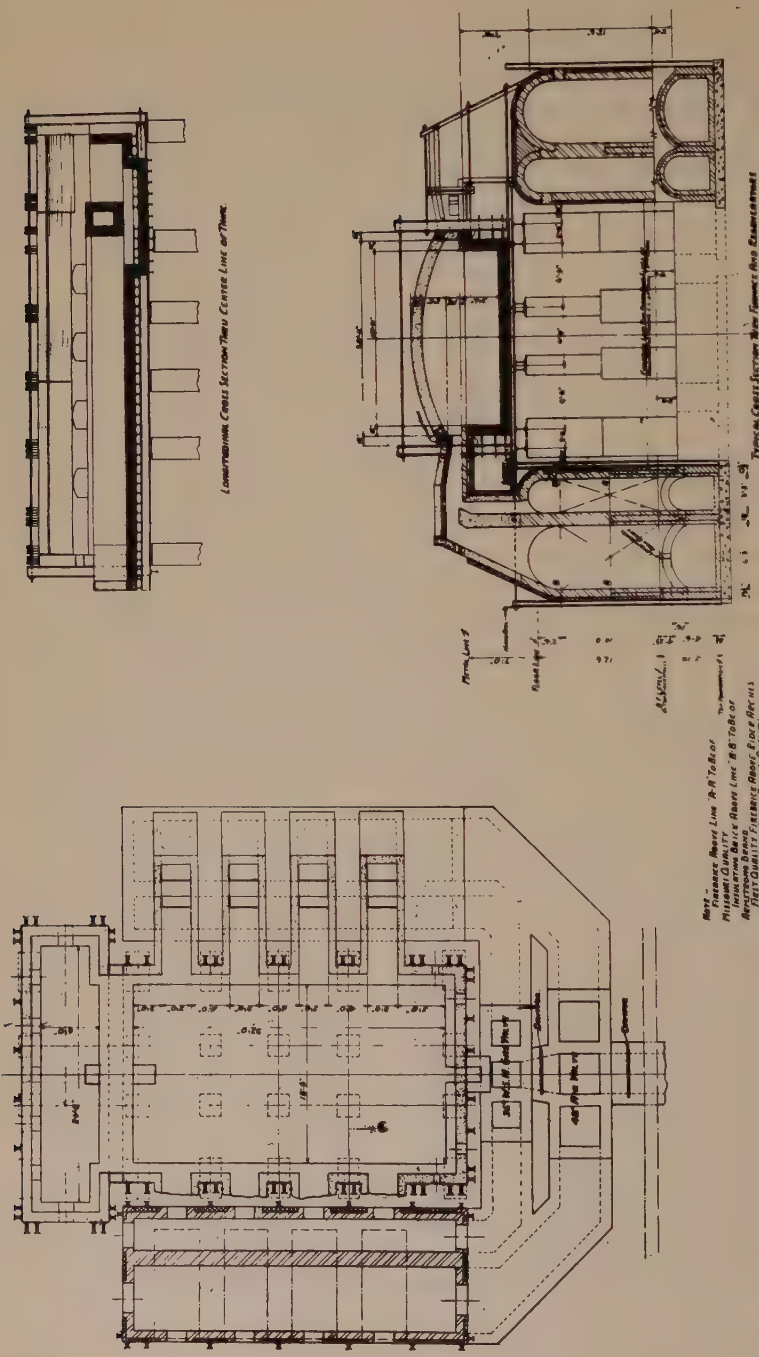
The first impression upon entering the factory is that of the intense heat. The furnaces, feeders and bottle machines are all radiating great quantities of heat, and it is a serious problem to maintain livable working conditions. Prostrations are not infrequent in the summer months. In the days of hand blowing it was customary to shut down the factory during July and August, during which time the necessary repairs to furnaces were made. However, investments involved in modern equipment require continuous operation throughout the year.

Present-day glass furnaces are extremely wasteful of heat, and improvements in design will have the dual advantage of fuel economy and increased production due to better working conditions resulting from lower factory temperatures. Some relief is experienced from the use of insulation, but this results in higher temperatures in the materials which are insulated, and the difficulty lies in securing refractories that will stand up under the combination of great heat and exposure to molten glass. Considerable progress is being made in the problem of securing suitable refractories. Within the last two years refractory materials have been developed which have given two and one-half times the usual life, and such refractories are now being manufactured on a commercial scale. Progress has also been made on entirely new types of furnace design which involve the usual principles of waste heat utilization.

The factory building must be laid out with ventilation features receiving maximum consideration. The writer's conception of the problem is as follows: Large volumes of hot air are rising at slow velocities from the equipment. Ample air inlets in the form of areaways should be provided in the basement to allow easy air ingress. The usual solid wall between the working floor and the window sills should be omitted and pivoted shutters installed which may be opened in hot weather. Openings in the working floor around the furnaces with gratings should be provided. The distance from the floor to bottom chords of roof trusses should be made at least 25 feet, and preferably 30 feet. The roof contour should be of such shape as to allow unobstructed flow of the slow moving air currents. Finally, proper air egress must be provided at the highest levels. Ventilated steel sash is open to suspicion due to the effect of varying wind direction, and consequently roof ventilators of ample area and proper location should be provided. It is well to mount these on shafts extending well above the roof. The ventilators are to be considered merely as air outlets, shaped to keep out the weather, but with minimum obstruction to air flow. Let the cool air enter the building at as low an elevation as possible, and let it leave at as high an elevation as possible, and provide proper channels for its easy flow during its progress. During the hottest weather it is also necessary to introduce air from fans for man cooling.

The above conclusions are not original with the writer, but have been developed from many discussions with glass factory operatives who regard this as one of their greatest problems. All of the above features have been tried as expedients to correct poorly designed factories, but the factories which include all the features of the ventilation system described are rare.

The furnaces perform the key operation of the process. In them the batch is melted and the molten glass refined until it is uniform, free from entrained gas, and of proper viscosity and temperature for making good bottles. While there is not space to cover in detail the design of


Longitudinal Cross Section Thru Center Line of Tank
Typical Cross Section Thru Furnace and Regenerators
Note – Firebrick Above Line "A-A" To Be of Missouri Quality
Insulating Brick Above Line "B-B" To Be of Armstrong Brand
First Quality Firebrick Above Ridge Arches To Line "AA" To Be of Penna Quality

Courtesy The Amsler-Morton Company, Pittsburgh

FIG. 7. — REGENERATIVE GLASS FURNACE

the furnaces, a brief description will be of interest. Reference should be made here to Fig. 7 which illustrates a glass furnace similar to the ones to be used in this plant. The furnaces will be of the regenerative type; that is, each will consist of a glass melting tank 18′ x 24′ x 42″ deep, with a combustion space above. It is mounted on brick piers and steel beams and is located between the two regenerators. The tank is wholly enclosed and has an arched roof. Each regenerator has a gas and an air compartment filled with checker brick. Ports connect the melting tank with the regenerators. Under the regenerators are gas and air passages leading to the gas and air reversing valves, respectively, as shown on the figures. Air enters the latter from the basement and gas enters the gas valve from the producer mains. There is a common exhaust duct leading from the reversing valves to the chimney. Each furnace has its own chimney.

Operation is as follows: For twenty minutes air and producer gas enter one regenerator, passing *up* through its hot checkers. Gas and air unite over the regenerator uptakes, the resulting combustion making a gas flame which sweeps across the surface of the molten glass leaving the tank via the ports of the cooler side, and giving up its heat to the glass which attains a temperature of about 2,500° F. The waste gas passes *down* through the outgoing regenerator heating its checkers and finally escaping to the atmosphere, passing through the gas and air valves and the chimney on its way. After twenty minutes the gas and air valves are reversed and the cycle occurs in the opposite direction to that described, both the incoming gas and air absorbing heat from the hot checkers of the incoming regenerator. This is no different from the regenerative principle of an open hearth steel furnace.

The batch charge is fed into an opening at the charging end of the tank called the "dog house." This is the only part of the furnace which is open to the air, and this opening is sealed up immediately after charging. At the opposite end of the melting tank there is a ventilated "bridge wall" 42 inches high through which there is a submerged "throat" 12″ x 18″ in section leading to the refining chamber which is of similar construction to the melting tank. As the molten glass is withdrawn by the feeders the glass flows at a very slow rate from the melting tank through the throat to the refining chamber or "nose." The feeders are arranged to withdraw the glass from the nose and deliver it in gobs of the exact weight required for the bottle being made.

The furnace throughout is, of course, constructed of refractory materials with steel supporting beams, buckstays, and tie rods. Several different types of refractories are required in the different parts. Walls and floor of the tank are made of "flux" blocks low in silica, as refractories with high silica content cannot be allowed to come in contact with the molten glass. Silica brick are used for the arched roof, as this portion is exposed to high temperatures. First and second grade fire brick are used in the regenerators, portions of which are insulated. Refractory blocks of special shape are used in various parts.

The design of the furnace consists in providing proper melting and refining areas and combustion space; adequate areas for ports and other gas passages; proper checker volumes in regenerators; and sufficient chimney action in the regenerators and uptakes.

An important feature of the design involves a careful study of the flow of the glass from the dog house to the feeders. "Dead" corners, especially in the nose, must be avoided, as channels are apt to form, in which the glass is of different composition from the slower moving borders. Feeders must be located so as to avoid uneven flow of this nature. An insufficient melting area results in too rapid withdrawal, causing "seedy" glass in which gas bubbles are formed resulting in imperfect ware.

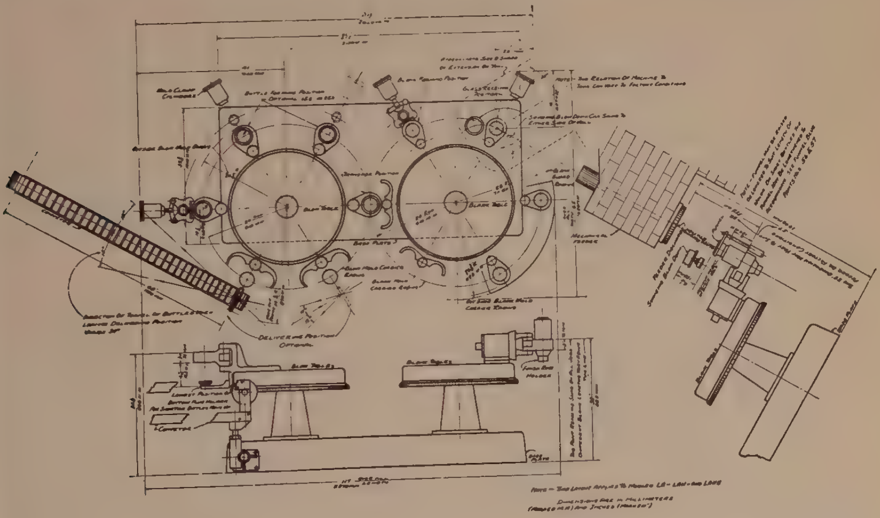
While the theoretical basis of design is very empirical, there are many details which practice has shown to be important and which require careful attention. The furnace is constructed in such a manner that the side wall blocks of the melting tank may be replaced without disturbing the remaining structure. With the present type of flux blocks these walls dissolve or erode, and portions are practically destroyed by the glass in a period sometimes as short as eight months. When these walls become dangerously thin, expedients are adopted which increase the life of the tank, but it finally becomes necessary to shut down the furnace to make repairs. The molten glass is then withdrawn and sent to the cullet storage and the tank blocks replaced. This will take some six weeks during which production is lost from the furnace and its contingent bottle machines and lehrs.

To maintain the tank for its maximum life, an extensive wind cooling system is installed consisting of galvanized ducts with numerous outlets delivering wind on the tank walls and floor. The dog house corners, the submerged throat, and the port sills are found to give out first, and consequently these have additional cooling facilities in the form of water boxes through which water is constantly circulated. When the furnace is completed it is slowly warmed up with a drying-out fire for a week or two, after which it is charged with batch and cullet and its temperature gradually brought up to normal. Buckstay tie rods have to be adjusted during the process. Care has to be exercised at this stage to avoid explosions. Four weeks may be taken as an average time for the starting up period. After the bottle machines are started, it will take several days of various adjustments before normal efficiency of production is obtained.

The above description is necessarily very much abbreviated, and there are numerous problems in furnace design and operation which have not been touched upon.

Bottle Machines, Feeders and Lehrs

This factory will have initially nine Lynch bottle machines, three operating from the old furnace and three on each of the two new furnaces. An "L A" Lynch machine is shown on Fig. 8. Each machine is served by one feeder which delivers the glass from the furnace to the machine. A feeder consists of a trough-shaped, enclosed horizontal channel, at the machine end of which is an orifice through which the glass is delivered. When this orifice is opened a gob of glass is extruded and cut off by a steel shear operated by compressed air and timed to the machine speed. The gob drops a few inches and compacts into the first blank mould of the bottle machine. The "L A" machine consists of two six-arm revolving tables, the arms of one table containing "blank"



Courtesy Lynch Glass Machinery Company

Fig. 8. — Lynch Bottle Machine — Type "L A"

moulds, and the other the "blowing" moulds. At the second stage of the blank table the bottle is "blank formed." At the third stage the mass of glass, which now has the outer form of a bottle, is transferred to the blowing circle. The blowing of the bottle occurs in the second stage of this circle, the third and fourth arms being holding stages. In one or the other of these stages, air at a reduced pressure enters the blown bottle and holds it to shape until it has cooled sufficiently to be self-sustaining. At the fifth or sixth stage of this table, the finished bottle is "set out" on to a conveyor. It will be noted from the figure that the "blowing," "holding" and "set-out" processes may occur at later stages than given above.

The machines are operated by compressed air at 35 to 40 pounds' pressure. This pressure is reduced for the actual blowing of the bottles in the blowing moulds. There is, of course, a great deal of heat liberated during the process, and consequently each machine has to have nine or more cooling wind pipes which blow air on to the pins, hinges and various other parts of the moulds to keep them from overheating. Many factories receive the wind for this purpose from an overhead system, but it is preferable to deliver it from a chamber at the base of the machine, thus eliminating overhead duct work. This wind system is independent of the furnace cooling system.

Each machine has one operator who keeps the various parts lubricated, weighs occasional bottles, adjusts the cooling wind, watches the feeder delivery, and hunts trouble in general. A high grade of labor is requisite for this stage of the operation.

Up to within the last year or two, "carry-in" boys have had to be employed to take each bottle from the bottle machine conveyor and place it in the lehr. An automatic "stacker" has now been developed to lift the hot bottle from the conveyor and place it in the lehr. These stackers have proven practicable and they will be included in the new layout. While the initial expense in equipment is increased, the operating costs are greatly reduced, due to the elimination of the "carry-in" boys. Much less open space occurs between the bottle machines and the lehrs where stackers are used. A more compact arrangement results which is desirable, provided proper cooling facilities are installed for the operators working in this rather restricted space.

This factory, when remodeled, will operate nine lehrs, or annealing ovens. Proper annealing is a very important part of the process of bottle manufacture. When glass is cooled rapidly it becomes strained and will shatter with slight shocks and change of temperature. These strains must consequently be removed before the bottle can be packed.

An annealing lehr supplies a slight additional amount of heat to the hot bottle to remove initial strains, and then allows it to cool gradually at a rate that prevents reappearance of strain during the cooling process. A polariscope is used to determine presence of strain. A more or less ideal annealing curve is shown on Fig. 9. It will be noted that in the upper range of the curve the cooling may be at a rapid rate which must be followed by a period of slower cooling. Below the critical point in the lower range of the curve more rapid cooling may be resumed.

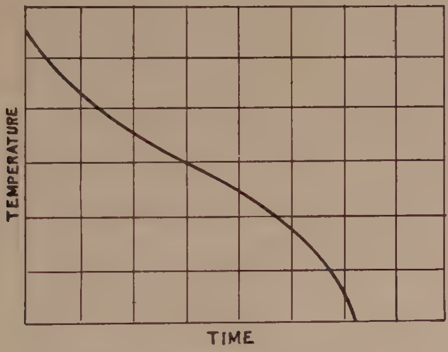


Fig. 9. — Ideal Annealing Curve

The front or furnace end of the lehr is heated and the bottle is gradually cooled as it moves slowly on the conveyor toward the cool end. The conveyor is enclosed in an insulated housing or tunnel provided with a draft control system to maintain a proper temperature gradient throughout its length. The proper gradient varies with the type and weight of bottle. A lehr of this type has a high efficiency when in normal operation; in other words, the loss due to poorly annealed ware is very slight.

The conveyor of the lehr extends several feet beyond the tunnel or enclosed section. At this point the bottles are inspected and packed. The packed cartons are placed on the power conveyor described elsewhere, on which they travel to the warehouse.

Producer Gas System

On Fig. 1 is indicated the producers and the overhead steel mains which conduct the gas to the furnaces. The mains consist of a riveted steel shell about 7½ feet in diameter (at largest section) and lined with 4½ inches of firebrick. Experience has shown that about 0.6 ton of coal gassified at the producer will supply the proper amount of producer gas to melt 1 ton of glass. Initially one heavy duty producer will be installed of a capacity to gassify 48 tons of coal each twenty-four hours, and provision is made for the later installation of a second producer. Producer gas is the product of the incomplete combustion of coal in a chamber to which there is a supply of steam and air. Completion of combustion occurs when the gas reaches the glass furnace and mixes with the air supply at that point. The producer consists of a steel shell lined with firebrick and having a steel or cast-iron top, on which the automatic coal feed is mounted. It is supported on a concrete foundation which has a circular basin forming a water seal through which the ashes are removed continuously. Agitation of the fuel bed has been found to increase greatly the rate of gassification, and automatic producers are provided with mechanically operated agitators and pokers for this purpose. The operation of the producer is continuous, the pressure of the outgoing gas being maintained at an amount sufficient to overcome friction in the mains and to deliver the gas to the gas valves at a pressure of about 0.75 inch (water column). The pressure will be from 1¼ to 3 inches at the producer. A regulator actuated from the pressure in the mains governs the supply of steam to the producer. The temperature of the gas at the producer will vary with method of operation and with the grade of coal. A good operating temperature is considered to be between 1,300° F. and 1,400° F. Excessive temperatures may result in combustion of the gas in the producer, or in clinkers if the coal has a low ash fusing temperature. Indicating pyrometers are connected with the gas space above the fuel bed.

Producer gas contains a large amount of fine, light soot. This soot is caused by the incomplete combustion of the coal at the producer, and also may contain finely divided unconsumed fuel dust which has become mixed with the gas at the producer, due to the action of the steam blower. The gas cleaning processes which are used in illuminating gas plants are not generally considered to be warranted in glass factory work; consequently, the problem becomes that of, first, best operation of the producers to obtain minimum soot by proper adjustment of coal and steam supply; and second, removal of the soot from the gas in the mains. The soot is so light that it is carried along with the gas, like smoke. It is important to remove a maximum amount at the producer necks before the gas enters the mains, and soot catchers are provided here for this purpose as indicated on Fig. 1. With the best of precautions at this point there is still a large volume of soot carried along with the gas.

Consequently the mains will have soot-removing traps along the line to be opened daily, and will also have provision for weekly burn-outs by the admission of air which supplies oxygen for combustion of the soot. During the burn-out period the producer dampers and the furnace dampers are closed and the damper in the by-pass from the mains to the chimney is opened to provide draft and to allow the products of combustion to escape. Combustion of *all* the soot in the mains by this method is in general not practicable, due to the time required, and if this method of disposal is to be depended upon, the mains should be designed with a sufficient area to allow for the appreciable volume of soot remaining in them after burn-out.

In a recently patented soot disposal system all of the soot in the mains is blown to an incinerator where it is completely consumed in 1½ to 2½ hours. Practical use of this system has demonstrated its success, and it promises one solution of this bothersome problem.

In some plants the gas mains are insulated with insulating brick placed between the firebrick lining and the steel shell. Insulation adds considerably to the first cost, as the steel shell has to be made of a greater diameter, and consequently the cost of the greater steel tonnage has to be added to the cost of the insulating material. One inexpensive and effective form of insulation that has been adopted consists of a 2-inch air space provided between the shell and lining at the top, relying upon the soot accumulation to insulate the base and sides.

Before leaving this subject, brief mention should be made of two other fuels which are often used for glass melting furnaces. These are natural gas and fuel oil. Natural gas has a high calorific value and is relatively inexpensive. It is used extensively, but some glass engineers consider producer gas to be better, claiming that there is a more even heat distribution throughout the furnace with consequent less severe duty on the refractories, as well as a more uniform quality of glass.

Fuel oil, while requiring expensive storage tanks, has a very simple air and oil piping system as compared with the large riveted steel producer gas mains. The operation of a furnace using fuel oil is clean and simple, but more expensive when measured in glass production.

There is a chimney for each furnace. The chimney serves the dual function of discharging the waste gas from the furnace during the week, and of providing draft for the gas main burn-out operation on Sunday mornings. The normal chimney gas temperature may be taken as about 600° F. and may rise to 2,500° F. during the burn-out period. Due to the high temperatures particular care must be taken in specifying the details of the stack and lining and the materials used. It is customary to inspect the chimneys at the time the furnace tank walls are being replaced, and frequent repairs are necessary. Many glass factory chimneys show cracks early in their life, due to failure to realize that this service is particularly severe. Radial brick stacks built to specifications that are standard for steam power plants will not stand up. This type may be used if special provisions are made for the temperatures noted. Very good results have been obtained from reinforced tile chimneys and also from steel stacks, both lined for the full height. Where the duct from the furnace is underground, particular care must be taken to leave proper air spaces between the duct and the adjacent concrete work, through which air should be circulated.

Warehouses and Conveying System

Most purchasers of bottles carry small stocks at their own plants, and consequently the manufacturers have to have large warehouse facilities. The warehouses are of simple construction. In general, they are of one story, consisting of a concrete floor at car level height with a light steel frame roof and corrugated iron sides. Lighting is less important than in shop areas. Heating is generally provided only in the office and toilet enclosures. Ramps to the ground with easy grades are generally provided for access of electric trucks or gasolene tractors. Fire protection may be provided by sprinklers, by interior hose stations, or by exterior fire hydrants in accordance with the owner's policy as to fire insurance. Truss heights, column spacings, location of bracing and similar details are arranged to fit the dimension of the storage piles.

Three methods of transportation of the packed ware from the packing room to the warehouses may be considered, *i.e.:*

1. Conveying system.
2. Trucking system.
3. Combined conveying and trucking systems.

The first system consists of an arrangement of power and gravity conveyors similar to that mentioned earlier in this paper. This system is economical to build and operate on sites such as that of the plant under consideration, where there is a considerable drop in elevation between packing room floors and the more remote warehouses. In the second system the cartons and crates are transported to the warehouses in trains of trailer trucks hauled by gasolene tractors or storage battery trucks. This system of transportation generally requires ramps, as the packing room is often at second story level.

These ramps take up considerable space and are expensive, due to their length, as the grades should not exceed 6 per cent for electric trucks, although they may be somewhat steeper for gasolene tractors. The trailers are of the transfer type allowing rapid loading and unloading of the skid platforms on which the cartons are piled.

In the second and third methods of handling there is the problem of providing proper floors to stand the traffic of the iron wheel trailers, as concrete floors will not properly stand this traffic. Rubber treads on the wheels, wood wheels, and fiber wheels have been tried on trailers. The rubber tires make it difficult to "man-handle" the load, and wood and fiber wheels are, in general, short-lived. Where iron-wheeled trailer trucks have to be used, traffic aisles in the warehouses should be paved with mastic paving or wood blocks, the remaining floor being of concrete. Mastic paving is very satisfactory, but, in the writer's experience, has proven to be more expensive in first cost than 2½ inch creosoted wood blocks.

In the warehouses the cartons, boxes or crates are stored in piles up to 18 and 20 feet high. Higher piles are uneconomical unless mechanical stackers are used. Soda or tonic bottles may be stored either in open trays or in bulk. Bulk storage piles 15 feet high are not infrequent, and the consequent floor loads are heavy.

Conclusion

The interesting features of a bottle plant from the engineer's point of view lie in proper selection and arrangement of the various parts of the equipment to give efficient operation, and in the provision of structures to serve this equipment. There are the usual structural problems in concrete and steel design, the one feature to which special attention must be given being the high temperatures of furnaces, regenerators and gas ducts. Consequently especial care has to be taken in protecting concrete work adjacent to these parts.

Relative floor elevations and the fitting of the plant to the ground has to be given careful study. The tendency in glass furnace design is toward deeper regenerators. The regenerators and their gas and air ducts form a considerable proportion of the factory basement area. Consequently from the construction point of view, to avoid water troubles and possible rock excavation over this extensive area, it is desirable not to have the basement floor level much below the outside ground level. Fortunately, this is also desirable from an operating viewpoint, as with the basement approximately at ground level the working floor and packing room will be at a desirable elevation for the conveyors serving the warehouses.

Finally, the various buildings of the plant should be placed so as to give a proper street layout for general yard traffic, for the convenience of the local fire department, and to make possible a good arrangement of the various distribution mains which are necessary for the operation of the glass bottle plant.

OF GENERAL INTEREST

A VACATION SUGGESTION

A Few Notes and a Sketch this Summer will Provide Material for Interesting Articles Next Winter

There are many interesting old structures in out of the way places which one comes across on his summer vacation. Sometimes there are entertaining stories to go with these. Generally some local old-timer is only too glad to go into their history in great detail. Perhaps this bit of history may stray somewhat from the truth, but, nevertheless, it would make interesting reading. If you should happen to find a case like this in your travels this summer, why not take a few notes and perhaps a snapshot and write up an article for this section of the JOURNAL next fall.

Those who visit the sections of New England which were flooded last year will certainly hear stories of the destruction of buildings and bridges and of the freaks played by the water. This will make interesting reading.

Perhaps farmer Jones has at last succeeded in building a wharf out in the lake which will withstand the force of the winter's ice. Jones is probably not an engineer, but we all might learn something from his commonsense and would be interested in seeing a sketch or a photograph of his wharf, together with a description of it and a description of the ones that have failed.

Many of the farmhouse water supplies are interesting and ingenious. It is quite a problem on many farms to get a convenient water supply, and there are almost as many different schemes as there are farms. Why not write up a description of the one where you stop this summer?

You will undoubtedly get as much pleasure in writing one of these articles for "Of General Interest" for the JOURNAL as we will in reading it, and only by the co-operation of all of us can this section of the JOURNAL be made truly one "of general interest."

Tides and Currents in Boston Harbor

A new publication of the United States Coast and Geodetic Survey on the Tides and Currents in Boston Harbor, which should be of interest to engineers locally, is announced by Lieut. Comdr. R. F. Luce, in charge of the Boston office of that service.

The purpose of this volume, which is one of a series covering the important waterways of the United States, is to make available the tidal and current data which have been collected by the Coast and Geodetic Survey. In the preparation of the publication it was the aim to give in considerable detail the results of all observations in Boston Harbor and vicinity, including the special tidal and current survey made by that service in 1926.

A rather complete historical description is given of all tidal and current observations which have been made since the first series in 1847, and this goes into considerable detail regarding the various changes which have occurred in bench marks and staff during the first long tidal series at the Charlestown dry dock.

Elevations and descriptions of all bench marks in the vicinity of Boston are included, together with relations between various data used by engineering organizations.

Numerous maps show the location of all tidal and current observations, and a series of charts shows, for each hour after high and low water, the strength and direction of the current at numerous points in the harbor.

Among the tables included are synopses of all tidal and current series and observed water temperatures and densities, and the publication closes with a treatise on the general characteristics of tides and currents.

Publicity for Engineers

*By Edward Grossman**

"A flat wheel makes the most noise," is a saying in railway circles; or, in other words, noise and poor work are synonymous. This is true of car wheels, although it is worth noting that the wheel which is true receives no attention beyond the usual inspection, while the flat wheel gets the vacation. True worth is not always appreciated.

The advocates for publicity for the engineer have to contend with the "flat wheel" proverb. A good engineer, it is said, should make no noise, but let his works speak for him. This would be good advice to follow in so perfect a place as heaven, but in this imperfect world every man must speak for himself. The engineer's work is never seen by the public — it is only the results that are visible, and even they may be concealed by masses of masonry. The reasoning of opponents to publicity is, therefore, fallacious.

The man on the street knows that somewhere in town there are beings who juggle with figures and design structures. He may see one of them once in a while; he never hears them, that is certain. They say nothing, so why should he? Therefore he takes his buildings, bridges, streets, railways, water supply, and other conveniences for granted, and that is that.

It is unthinkable, of course, that the public takes engineering feats for granted because of its traditional cynicism or because of lack of interest in the doings of every one except the moving-picture actor. Neither would one like to think that the public does not consider the importance of the engineer's work.

There is no doubt but that the engineer is a useful member of society; that he is not fully appreciated; and that society is in need of his services in every phase of its activities. But until the engineer comes out of hiding and toots his own horn, he will not be known; he will not be appreciated; he will not get that wider opportunity to serve that he ought to get.

Granted that the engineer should receive publicity, let us not be led astray by extremists. Publicity does not mean cheap talk or buncombe. Publicity does not mean vociferous self-pity. Publicity means only that the engineer obtain the same consideration in the public mind as that to which his profession and his status entitle him. It also means that he do his duty to society by letting the public know of his doings, that his capacity for service may be gauged, and advantage taken of it, to the gain of both himself and the public.

---

* With Benjamin Steinberg, Contractor, Boston.

No one is completely self-sustaining; each one depends on someone else for his daily needs. The engineer is dependent on the farmer, the manufacturer, the merchant, the transportation man, just as they are dependent on him to put his knowledge to their use so that their needs can be satisfied. Thus all human beings are mutually interdependent.

Each member of this vague commune known as "society" is responsible to it as a whole, since the well-being of all depends on each. A duty each owes to society is to let it know of his doings. There is not only mutual interdependence, but also mutual responsibility of which cognizance must be taken. This responsibility cannot be avoided.

Bankers have their financial page, physicians have their health articles, criminals and their satellites have special reporters assigned to record their doings. This is as it should be, for society has a right to have the news. Yet the most useful of professions blooms unseen in the wilds of the drafting rooms which the public almost never sees and seldom hears about. Thus far engineers have been reticent because they do not realize their position. Slowly, however, their path of duty is being marked out, — the path of intelligent leadership. This is what the world seeks at the present time, but it does not know where to turn, for the simple reason that it has not been educated as to the place to seek this intelligent leadership. And the education will come only through publicity.

Publicity for engineers is not only desirable, but also imperative, because the engineer, like every one else, owes a certain duty to the community, and in order to help him discharge it, a knowledge on the part of the public of the activities of the engineering profession is of assistance. What publicity is desirable, and what are the ways to obtain it?

At the present time two methods of publicity should be encouraged, — the first is insistence on professional credit, and the second is newspaper publicity.

It is the custom, especially in the architectural press, to print the name of the architects with illustrations of a building. Full professional credit is given to the architect; but what of the engineer? While it is true that the results of the engineer's work are hidden behind the ornamentation of the structure, his part is fully important enough for him to receive credit for his work. Why should not an illustration of a building be captioned "Blank Building. Jones & Jones, Architects; Smith & Smith, Engineers," instead of the engineers not being mentioned at all?

The second method of publicity — press notices and the like — should be cultivated not only for the good of the profession, but also for reasons previously set forth. Press notices must be prepared in accordance with the usual journalistic style, with the news-interest part, not the technical-interest part, foremost. The public grasps personalities and particularities quicker than it does technicalities, and the former have more news value.

In general, the most common forms of press notices would be descriptive of the monthly meetings. These notices may be prepared in advance, with general details, such as attendance, a list of the more prominent engineers present, and similar items to be filled in after the meeting is over. In all cases it must be remembered that the speaker is the important person, and his remarks or lecture should be so written out that they would be of interest to the public, and so make good newspaper "copy."

Publicity must not contain propaganda of any sort, and must at all times be dignified and conservative in tone. Engineers are not given to exuberances and extravagances; therefore their publicity should befit them.

Publicity, conducted in a dignified manner, will not only serve the public as an educational agency, but will tend to raise the status of the engineering profession as a whole, and will thus benefit all. The results will be worth the effort.

Civil Engineer Appointed Chairman of Public Service Commission

Hon. John W. Storrs, a member of the Boston Society of Civil Engineers for over twenty years, is now chairman of the New Hampshire Public Service Commission. His designation last February to that position appears to be the first instance of a civil engineer being appointed to the position of chairman of a state public service commission. This appointment tends to reflect credit upon the engineering profession as a whole.

Mr. Storrs' entire life has been devoted to engineering problems, his specialty being bridge engineering. He is hale and vigorous, notwithstanding his sixty-eight years young. From 1895 to 1911 he was engineer for the Boston & Maine Railroad. From 1911 to 1918 he was engineer to the Public Service Commission of New Hampshire. In 1918 he was appointed a public service commissioner, which position he has held to this time. Although a public service commissioner for ten years, he has never relinquished his profession as an engineer, his firm "Storrs, Engineers," still functioning in the city of Concord, New Hampshire.

PROCEEDINGS OF THE SOCIETY

MINUTES OF MEETINGS

Boston Society of Civil Engineers

May 9, 1928. — A regular meeting of the Boston Society of Civil Engineers was held today in Chipman Hall, Tremont Temple, and was called to order by the President, Charles B. Breed, at 7.15 P.M. This meeting was held jointly by the Society and the Designers Section, B. S. C. E. There were about 120 members and guests present.

The minutes of the previous meeting (March 21, 1928) were approved as printed in the April Journal.

The President reported that the following had been elected to membership in the Society:

April 18, 1928. *Grade of Member:* John C. Davidson, Raymond C. Hastings, Lloyd C. Latimer, Charles W. Newcomb, Alexander C. Peters. *Grade of Junior:* Michael J. Linehan.

May 9, 1928. *Grade of Member:* George H. Delano, John H. Keane, Harvey B. Kinnison, Francis T. McAvoy, Karl G. S. Palm, Emil L. Palumbo, Francis P. Sammet, George A. Scott, George M. Weir, Walter E. Wheeler. *Grade of Associate:* Michael J. Fitzgerald. *Grade of Junior:* Mitchell W. Gowlowicz, Lloyd A. Ranlett.

The President announced the death of the following members of the Society, and stated that committees would be appointed to prepare memoirs:

George A. Smith, died January 16, 1928, a member since March 2, 1904.

Edward F. Murphy, died April 23, 1928, a member since June 19, 1907.

William L. Miller, died April 25, 1928, a member since May 17, 1899.

It was announced that the Board of Government had voted to omit the regular June meeting of the Society, and that a Joint Outing with the New England Water Works Association would be held at the New Ocean House, Swampscott, on Tuesday, June 26, 1928.

The President stated that the Board expected to recommend to the Society a change in the By-Laws with respect to the dues to be paid during the first half year by newly elected members. This would not affect the present members of the Society. This matter will probably be presented at the September meeting.

The President then introduced Dr. Howard T. Barnes, Honorary Professor of Physics at McGill University, who gave an address on "Ice Engineering," illustrated by slides and moving pictures. Dr. Barnes is a recognized authority on this subject, and his paper was of great interest. It presented a subject of much importance to the engineer, but one with which the average engineer is not very familiar. The paper is to be published in a fall issue of the JOURNAL.

A question and discussion period followed, and the meeting adjourned after according Dr. Barnes a vote of thanks.

J. B. BABCOCK, *Secretary.*

Northeastern University Section

APRIL 20, 1928. — The second regular meeting of the year of the Northeastern University Section of the Boston Society of Civil Engineers was held in Room 26, Huntington Building, with Chairman Karl H. Wilber presiding.

Nominations for officers for the ensuing year were made from the floor. The following were elected:

Chairman — Harold L. Burton, 1929.
Vice-Chairman — F. Gordon Smethurst, 1929.
Clerk — Kenneth D. Sylvester, 1929.
Executive Committee — Arthur M. Mager, 1929, Bernard A. O'Shea, 1929, Charles S. Richardson, 1929.

After the election of officers Chairman Wilber spoke briefly on the activities of the Section during the past year, and thanked the officers and members for their co-operation in promoting the welfare of the Society.

The speaker of the evening, Mr. Walter C. Voss, Structural Engineer, Portland Cement Association, was introduced by Chairman Wilber.

Mr. Voss spoke on the subject, "Light Weight Concrete." This is an exceptionally new subject, particularly in its application to practical purposes.

Mr. Voss described several kinds of light-weight aggregates and the use of light-weight concrete in the government ships during the World War.

Due to his wide experience in concrete problems Mr. Voss delivered to the members much first-hand information that could not be obtained otherwise. After his talk he answered questions on the subject.

Professor Alvord made a few brief remarks on the subject of concrete mixtures.

Several of the Alumni of the School of Engineering were present.

Prior to the meeting the members had dinner at the Café de Paris.

Meeting adjourned at 9.30 P.M.

Respectfully submitted,
KENNETH D. SYLVESTER, *Clerk.*

APPLICATIONS FOR MEMBERSHIP

[June 20, 1928]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of fifteen (15) days from the date given.

For Admission

Bird, Russell Wyeth, Jamaica Plain, Mass. (Age 21, b. Jamaica Plain, Mass.) Attended High School of Commerce for three years, until 1924. Experience: security clerk, Weld, Green & Co., brokers, until March, 1926; from March, 1926, to March, 1928, in charge of field work with J. Leslie Woodfall. Attended Franklin Union evenings during the fall of 1927. In March, 1928, opened an office in Waverley with Joseph W. Kalinsky as partner. Refers to *M. E. Deacon, J. W. Kalinsky, I. J. Rosenfield, K. S. Ulm, J. L. Woodfall.*

NEW MEMBERS

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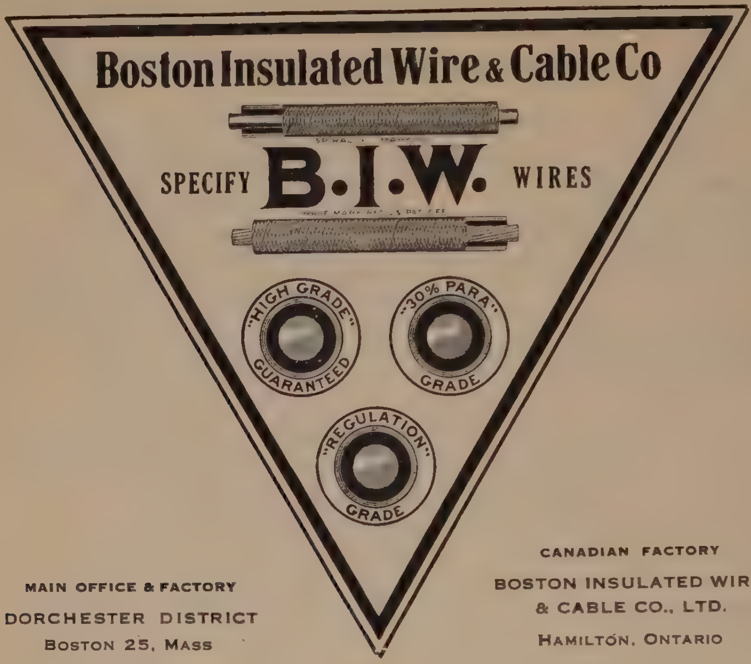

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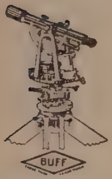

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